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ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

Joseph Frederick Whiteaves, LL.D., F.G.S., F.R.S. (Canada).

Palæontologist, Zoologist, and Assistant Director, Geological Survey of Canada; Hon. Memb. Ashmolean Soc. Oxford, Yorkshire Phil. Soc., Nat. Hist. Soc. Montreal, and Hist. and Scient. Soc. Manitoba.

(WITH A PORTRAIT, PLATE XXIII.)

WE are glad to introduce to our readers a portrait and some account of the life-work of the distinguished Palæontologist to the Geological Survey of Canada, who has now held the office for thirty years.

Dr. Whiteaves was born at Oxford on the 26th of December, 1835, and resided in that city until 1861. In early life his attention was attracted to the pursuit of Natural History, and during the years 1855 and 1856 he collected and studied the land and fresh-water mollusca of the neighbourhood of his home, and communicated a paper thereon to the Proceedings of the Ashmolean Society. His energies were afterwards directed to geology, and during the years 1858 to 1860 he spent most of his time in collecting and studying the Jurassic fossils, and more particularly those of the Lower and Middle Oolites, of the country around Oxford. At this period the present Master of Pembroke (Bishop Mitchinson), the Rev. H. H. Wood, and Mr. James Parker were zealous collectors of fossils at Oxford. In 1861 Dr. Whiteaves published lists of the fossils thus obtained, and thereby added quite a large number of species to those previously known from the Great Oolite Series and the Corallian rocks. Many of the fossils upon which these lists were based were exhibited at the meeting of the British Association at Oxford in 1860, at which Sedgwick, Lyell, and Salter were present. Several of the species in these collections were then new to science. Four of them, from the Corallian, were described and figured by Dr. Whiteaves in the *Annals* for May, 1861. Fourteen others, from the Lower Oolites, were described and illustrated by the late Dr. John Lycett, in 1863, in his "Supplementary Monograph on the Mollusca of the Stonesfield Slate, Great Oolite, Forest Marble, and

Cornbrash," published by the Palæontographical Society. Professor John Phillips, who then occupied the Chair of Geology at Oxford, took a lively interest in these palæontological investigations, and subsequently referred to them in complimentary terms in his "Geology of Oxford and the Valley of the Thames." Dr. Lycett also called attention to the discovery by Dr. Whiteaves of Bradfordian species at Islip, while subsequent workers in the same field, Mr. E. A. Walford, Professor J. F. Blake, and the officers of the Geological Survey, have acknowledged the value of these original researches.

At intervals, during his residence at Oxford, Dr. Whiteaves collected at other famous localities for Oolitic fossils, such as Minchinhampton, and the neighbourhood of Stroud, Cheltenham, Dundry, and Bath. He also did a little amateur dredging on the coast of South Wales, near Swansea; at Lamlash Bay, Arran; and off St. Heliers, Jersey. He was elected an Honorary Member of the Ashmolean Society at Oxford in 1857, and a Fellow of the Geological Society of London in 1859.

In 1861 Dr. Whiteaves paid his first visit to Canada, landing in Quebec early in June. After spending a few months at and near that city and Montreal, he went with E. Billings (Palæontologist to the Geological Survey of Canada[1]) to examine some fossiliferous exposures on the Yamaska River, near St. Hyacinthe. In the middle of December the tidings of the recent death of his father reached him in Montreal, and he at once returned to England, landing in Liverpool early in January, 1862.

A few months later he recrossed the Atlantic, and visited New York, New Haven, Philadelphia, Burlington (New Jersey), and Cincinnati. At these cities he made the acquaintance of Thomas Bland, Benjamin Silliman, J. D. Dana, Isaac Lea, G. W. Tryon, and J. G. Anthony. He spent the remainder of the summer of 1862 in Ohio, collecting and studying the land and fresh-water shells, and especially the Unionidæ, of the State, at Waynesville, Franklin, and Columbus. He returned to Montreal *viâ* Lakes Erie and Ontario in the late autumn of 1862.

From 1863 to 1875 Dr. Whiteaves was Curator of the Museum and Recording Secretary of the Natural History Society of Montreal. During these twelve years he worked in its interests with Sir J. W. Dawson, Dr. T. Sterry Hunt, Dr. A. R. C. Selwyn, Elkanah Billings, Dr. P. P. Carpenter, George Barnston, Professor R. Bell, and others, and was a rather frequent contributor to its official organ, the *Canadian Naturalist and Geologist*, which had been founded in 1856 by E. Billings. His special objects of study while connected with this Society were, first, the land and fresh-water mollusca of Lower Canada, now known as the Province of Quebec; secondly, the fossils of the Trenton, Black River, Chazy, and Calciferous formations of the Island of Montreal and its immediate vicinity; and thirdly, the marine invertebrata of Eastern Canada. He carried on dredging

[1] Elkanah Billings, F.G.S., was born in the township of Gloucester, near Ottawa, in 1820. He was appointed Palæontologist to the Geological Survey of Canada in 1856, and died in 1876. See Obituary, GEOL. MAG., 1877, pp. 43–45.

operations in the Gulf of St. Lawrence on behalf of the Montreal Society in 1867 and 1869, and under the direct auspices of the Department of Marine and Fisheries at Ottawa, which provided special facilities for this work, on Government vessels, during the years 1871, 1872, and 1873. In aid of this work Dr. J. Gwyn Jeffreys presented him in 1868 with a dredge of the most approved pattern. On an ordinary Gaspé fishing-boat it had been scarcely practicable to dredge at much greater depths than 50 or 60 fathoms, but on one or other of the fishery protection cruisers the greatest depths in the Gulf, from 200 and 250 to 313 fathoms, were for the first time successfully explored.

Sir J. W. Dawson has shown that the Pleistocene deposits of the St. Lawrence valley consist largely of a thin upper layer of sand, the 'Saxicava sand,' which is characterized by the abundance of a few common species of littoral marine shells and barnacles belonging to species still living; and of a lower and thicker deposit of clay, the 'Leda clay,' which holds the remains of a rich marine fauna of a distinctly deeper water type. The dredgings in the River and Gulf of St. Lawrence by Sir J. W. Dawson, Dr. Whiteaves, and others have so far shown that nearly all the species that have been found fossil in the Leda clay are still living in its waters, or in the North Atlantic. The principal exceptions seem to be the *Lepralia quadricornuta* of Dawson and the *Astarte Laurentiana* of Lyell, neither of which has yet been met with in a living state. *Tethea Logani*, Dawson (a tetractinellid sponge), was long supposed to be an extinct species, but Mr. L. M. Lambe thinks that it is the same as the recent *Craniella cranium* (Muller). The *Choristes elegans* of Carpenter, which was also once supposed to be an extinct species, has been dredged living by Verrill in deep water off the New England coast. The so-called *Leda* of the 'Leda clay,' now called *Portlandia glacialis* (Wood), has not yet been found living in the River or Gulf of St. Lawrence, though Mr. A. P. Low dredged a few fine living specimens of it at Richmond Gulf, on the east side of Hudson Bay, in from fifteen to twenty-five fathoms, in 1899. In this connection it may be mentioned that Dr. Whiteaves materially assisted in the preparation of the lists of Pleistocene fossils in the "Geology of Canada," published by the Geological Survey in 1863, and in the "Canadian Ice Age," published by Sir J. W. Dawson in 1893.

In 1875 Dr. Whiteaves joined the palæontological branch of the Geological Survey of Canada at the request of E. Billings, who was then in failing health. He was appointed Palæontologist to that institution in the autumn of 1876, shortly after the decease of Mr. Billings in June of that year, and was made one of the original Assistant Directors in 1877, and Zoologist in 1883.[1] During the

[1] The Assistant Directors were originally four in number, viz., Dr. Robert Bell, now Chief Geologist also; Dr. G. M. Dawson, who died in 1901; Dr. B. J. Harrington, who resigned in 1881; and Dr. Whiteaves. Drs. Bell and Dawson represented Field Geology; Dr. Harrington, Mineralogy and Chemistry; and Dr. Whiteaves, Palæontology. Dr. G. C. Hoffmann and Professor Macoun were since appointed assistant directors, the former in 1883, the latter in 1887.

thirty years of his official connection with the Survey he has published three descriptive and illustrated volumes on Canadian Palæontology or rather Palæozoology, which were issued in parts at varying intervals; a "Catalogue of the Marine Invertebrata of Eastern Canada"; and rather more than 100 papers on Canadian Palæontology or Zoology. His palæontological publications are based chiefly upon specimens brought in by the field geologists or acquired from local collectors, but on various occasions he has personally gathered fossils at many localities in the provinces of Quebec, Ontario, and Manitoba. With Drs. A. R. C. Selwyn, Robert Bell, G. M. Dawson, G. C. Hoffmann, Professor Macoun, and other members of the Staff, he has sedulously and persistently striven to add to and improve the collections of the Survey, in the hope of forming as large a nucleus as possible of a Canadian National Museum, such as that which was contemplated by Sir W. E. Logan in 1853.

For the first twenty-five years of its existence, the Geological Survey of Canada was only a Survey of the two provinces now known as Ontario and Quebec. During those years its collections were almost exclusively confined to the illustration of the geology, geological economics, mineralogy, and palæontology of these two provinces. Since the confederation of all the Canadian provinces, which was commenced in 1867 and completed in 1873, the Survey has become a Geological Survey of the whole Dominion. It was definitely constituted a Natural History Survey, also, in 1877, and a distinct department of the Civil Service of Canada in 1890. Its Museum now contains large and important collections illustrative of the botany, zoology, ethnology, and archæology of the Dominion, as well as of its geology and palæontology. These collections, and the memoirs and papers that have been based thereon, represent the labours of two generations of specialists. In palæontology the Museum of the Survey contains the types of nearly all the species of fossils that have been described in its publications.

The premises in Montreal in which its collections were housed from 1852 to 1881 ultimately proved to be quite inadequate for their proper accommodation. The much larger and more commodious buildings at Ottawa, into which the Survey moved in 1881, are also now found to be far too small for its present and future requirements, and the foundation of a new building for the suitable housing of its present staff and collections was laid at Ottawa in 1905.

Dr. Whiteaves is one of the original Fellows of the Royal Society of Canada, and has contributed twenty-two papers to its Transactions. This Society was founded in 1881 by the Duke of Argyll, who was then Marquis of Lorne and Governor General of Canada. From 1882 to 1899 Dr. Whiteaves was an active member of the American Association for the Advancement of Science, and was elected a Fellow thereof in 1887. At its meeting in Montreal in 1882 he exhibited and read a paper on some remarkable fossil fishes that had recently been collected from the Upper Devonian rocks at Scaumenac Bay in the province of Quebec, and from the Lower

Devonian rocks at Campbellton, New Brunswick; and at its meeting at Columbus, Ohio, in 1899, he was the presiding officer in the Section of Geology and Geography.

With the exception of short visits to England and the Continent in the summer seasons of 1865, 1866, and 1868, Dr. Whiteaves has lived in Montreal from 1863 to 1881, and at Ottawa from 1881 up to the present time. In 1900 he received the honorary degree of LL.D. from McGill University, Montreal.

His name has been associated with one genus of Ordovician Pelecypoda, with two species of fossil fishes, with sixteen species of fossil invertebrata, and with six species of recent marine invertebrata. His "Catalogue of the Marine Invertebrata of Eastern Canada," issued by the Geological Survey of Canada in 1901, summarizes the information gathered, largely by himself, but also by Sir J. W. Dawson and various Canadian and United States workers. This volume is of considerable interest in its geological bearings—the distribution of the fauna as compared with that of Western Europe. The identical, the slightly divergent or representative species, and the distinct species furnish endless subjects of study.

The record of work accomplished by Dr. Whiteaves in almost every branch of zoology and palæozoology, and his untiring industry, are apparent from the full list of papers herewith appended.

LIST OF PAPERS AND OFFICIAL PUBLICATIONS BY J. F. WHITEAVES.

(The titles of volumes that were issued in parts are printed in small capitals.)

1857. "On the Land and Fresh-water Mollusca inhabiting the Neighbourhood of Oxford": Proc. Ashmolean Soc., Oxford, vol. iii, p. 110.

1861. "On the Invertebrate Fauna of the Lower Oolites of Oxfordshire": Rep. Brit. Assoc., 1860, Trans. Sect., p. 104.

"On the Palæontology of the Coralline Oolites of the Neighbourhood of Oxford": Ann. Mag. Nat. Hist., London, ser. III, vol. viii, p. 142.

"On the Oolitic Echinodermata of the Neighbourhood of Oxford": Geologist, vol. iv, p. 174.

1863. "On the Land and Fresh-water Mollusca of Lower Canada," parts i and ii: Canadian Naturalist and Geologist, ser. I, vol. viii, pp. 50 and 98.

Transatlantic Sketches.—I. "On the Little Miami River, Waynesville, Warren County, Ohio": Zoologist, London, vol. xxi, p. 8419.

1865. "On the Fossils of the Trenton Limestone of the Island of Montreal": Canad. Nat. and Geol., ser. II, vol. ii, p. 312.

1869. "On the Marine Mollusca of Eastern Canada": ibid., ser. II, vol. iv, p. 48.

"On some Results obtained by Dredging in Gaspé and off Murray Bay": idem, ser. II, vol. iv, p. 270.

1870. "Notes on some Canadian Birds": ibid., ser. II, vol. v, pp. 103 and 230.

1871. "Report on a Deep-sea Dredging Expedition to the Gulf of St. Lawrence": Rep. Dept. of Marine and Fisheries, Ottawa.

1872. "Report on a Second Deep-sea Dredging Expedition to the Gulf of St. Lawrence, with some Remarks on the Marine Fisheries of the Province of Quebec": idem, Ottawa, 1872.

"Deep-sea Dredging in the Gulf of St. Lawrence": Canad. Nat. and Geol., ser. II, vol. vi, p. 351.

"Notes on a Deep-sea Dredging Expedition round the Island of Anticosti, in the Gulf of St. Lawrence": Ann. Mag. Nat. Hist., ser. IV, vol. x, p. 341. Reprinted, with some alterations and additions, in the Canad. Nat., etc., ser. II, vol. vii, p. 86.

1873. "Report on Deep-sea Dredging Operations in the Gulf of St. Lawrence, with Notes on the Present Condition of the Marine Fisheries and Oyster-beds of part of that region": Rep. Dept. of Marine and Fisheries, Ottawa.

1874. "On Recent Deep-sea Dredging Operations in the Gulf of St. Lawrence": Amer. Journ. Sci., ser. III, vol. vii, p. 210.

"Notes on the Cretaceous Fossils collected by Mr. James Richardson at Vancouver and the adjacent Islands": Rep. Progr. Geol. Surv. Canada for 1873–4, p. 260.

1875. "On a Collection of Himalayan Birds recently presented to the Natural History Society by Major G. E. Bulger": Canad. Nat., etc., ser. II, vol. vii, p. 394.

"Notes on the Marine Fisheries, and particularly on the Oyster-beds, of the Gulf of St. Lawrence": idem, p. 336.

1876. Geological Survey of Canada. Mesozoic Fossils, Vol. I, Part 1.—(1) "On some Invertebrata from the Coal-bearing Rocks of the Queen Charlotte Islands, collected by Mr. James Richardson in 1872": Montreal, pp. 1–92, with ten plates and nine text-figures.

1877. "Critical Notes on Fossils collected by A. R. C. Selwyn and Prof. Macoun in the Valleys of the Peace, Athabasca, and Clearwater Rivers": Rep. Progr. Geol. Surv. Canada for 1875–6, pp. 96–106.

"On the Fossils of the Missinaibi and Moose Rivers collected by Dr. R. Bell in 1875": ibid., pp. 316–329.

Obituary Notice of Elkanah Billings, F.G.S., Palæontologist to the Geological Survey of Canada: Canad. Nat., etc., ser. II, vol. viii, p. 251.

1878. "Preliminary Report on some supposed Jurassic Fossils collected by Dr. G. M. Dawson in the Coast Range of British Columbia": Rep. Progr. Geol. Surv. Canada for 1876–7, pp. 150–159.

"On some Marine Invertebrata from the West Coast of America."—Being a critical list of about 125 species from the Strait of Georgia, Burrard Inlet, etc., with descriptions of a new Alcyonarian by Prof. A. E. Verrill, and of a supposed new lamellibranchiate bivalve by the writer: Canad. Nat., etc., ser. II, vol. viii, p. 464.

"On some Primordial Fossils from South-Eastern Newfoundland, with description of one new species": Amer. Journ. Sci., ser. III, vol. xvi, p. 224.

1879. Geological Survey of Canada. Mesozoic Fossils, Vol. I, Part 2.—(2) "On the Fossils of the Cretaceous Rocks of Vancouver and adjacent Islands in the Strait of Georgia": Montreal, pp. 93–190, and ten plates.

"Provisional List of the Fossils collected by Dr. R. Bell in 1877 between the Long Portage of the Missinaibi River and York Factory": Rep. Progr. Geol. Surv. Canada for 1877–8, p. 50.

1880. "On some Marine Invertebrata from the Queen Charlotte Islands."—Contains a list of 160 species, with descriptions of three new starfishes by Prof. A. E. Verrill, and of two new species of mollusca by the author: idem, 1878–9, p. 190B.

"On a New Species of *Pteriehthys*, allied to *Bothriolepis ornata*, Eichwald, from the Devonian Rocks of the North Side of the Baie des Chaleurs": Amer. Journ. Sci., ser. III, vol. xx, p. 132.

1881. "On some remarkable Fossil Fishes from the Upper Devonian Rocks at Scaumenac Bay, P.Q.": idem, ser. III, vol. xxi, p. 494.

"On some remarkable Fossil Fishes from the Devonian Rocks of Scaumenac Bay, with descriptions of a new genus and three new species": Canad. Nat., etc., ser. II, vol. x, p. 27.

"Description of a New Species of *Psammodus* from the Carboniferous Rocks of the Island of Cape Breton": idem, p. 36.

"On some Fossil Fishes, Crustacea, and Mollusca from the Devonian Rocks of Campbellton, N.B., with descriptions of five new species": ibid., p. 93.

"List of Fossils collected by Dr. R. Bell in Manitoba during the Season of 1880": Rep. Progr. Geol. Surv. Canada for 1879–80, p. 57C.

1882. "Note on the occurrence of *Siphonotreta Scotica*, Davidson, in the Utica Formation near Ottawa": Amer. Journ. Sci., ser. III, vol. xxiv, p. 278.

1882. "On a Recent Species of *Heteropora* from the Strait of Juan de Fuca": idem, p. 279.

1883. "On the Lower Cretaceous Rocks of British Columbia": Trans. Royal Soc. Can., vol. i, sect. iv, p. 81, with three text-figures.

"On some supposed Annelid Tracks from the Gaspé Sandstones": idem, p. 109, with two plates.

"Recent Discoveries of Fossil Fishes in the Devonian Rocks of Canada": American Naturalist, vol. xvii, p. 158.

1884. Geological Survey of Canada. Palæozoic Fossils, Vol. III, Part 1.—(1) "On some new, imperfectly characterised, or previously unrecorded species of fossils from the Guelph Formation of Ontario": Montreal, pp. 1–43, with eight plates and four text-figures.

Geological Survey of Canada. Mesozoic Fossils, Vol. I, Part 3.—(3) "On the Fossils of the Coal-bearing Deposits of the Queen Charlotte Islands, collected by Dr. G. M. Dawson in 1878": idem, pp. 191–262, with twelve plates.

1885. "Note on a Decapod Crustacean from the Upper Cretaceous of Highwood River, Alberta": Trans. Royal Soc. Can., vol. ii, sect. iv, p. 237.

"Description of a New Species of Ammonite from the Cretaceous Rocks of Fort St. John, on the Peace River": idem, p. 239.

"Note on the Possible Age of some of the Mesozoic Rocks of the Queen Charlotte Islands and British Columbia": Amer. Journ. Sci., ser. III, vol. xxix, p. 444.

"List of Marine Invertebrates from Hudson Strait, collected by Dr. R. Bell in 1884": Rep. Progr. Geol. Surv. Canada for 1882–3–4, Montreal, pp. 58–60.

Geological Survey of Canada. Contributions to Canadian Palæontology, Vol. I, Part 1.—(1) "Report on the Invertebrata of the Laramie and Cretaceous Rocks of the vicinity of the Bow and Belly Rivers and adjacent localities in the North-West Territory": Montreal, pp. 1–90, and eleven plates.

1886. "Colonial and Indian Exhibition. Catalogue of Canadian Pinnipedia, Cetacea, Fishes, and Marine Invertebrata exhibited by the Department of Fisheries of the Dominion Government": Ottawa, pp. 1–42.

1887. "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada," part 1: Trans. Royal Soc. Can., vol. iv, sect. iv, pp. 101–110, with five plates.

"On some Marine Invertebrata, dredged or otherwise collected by Dr. G. M. Dawson in 1885 on the Coast of British Columbia, with a supplementary list of a few land and fresh-water shells, fishes, birds, etc., from the same region": idem, pp. 111–137, with four woodcuts.

"Notes on some Mesozoic Fossils from various localities on the Coast of British Columbia, for the most part collected by Dr. G. M. Dawson in the Summer of 1885": Annual Report, Geol. Surv. Canada, New Series, vol. ii, pt. B, pp. 108–114.

"On some Fossils from the Cretaceous and Laramie Rocks of the Saskatchewan and its Tributaries, collected by Mr. J. B. Tyrrell in 1885 and 1886": idem, pt. E, pp. 153–166.

1889. "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada," part 2: Trans. Royal Soc. Can., vol. vi, sect. iv, pp. 77–96, with six plates.

Geological Survey of Canada. Contributions to Canadian Palæontology, Vol. I, Part 2.—(2) "On some Fossils from the Hamilton Formation of Ontario, with a list of the species at present known from that formation and province"; (3) "The Fossils of the Triassic Rocks of British Columbia"; (4) "On some Cretaceous Fossils from British Columbia, the North-West Territories, and Manitoba": Montreal, pp. 91–196, with fifteen plates.

1890. "Descriptions of eight New Species of Fossils from the Cambro-Silurian Rocks of Manitoba": Trans. Royal Soc. Can., vol. vii, sect. iv, pp. 75–83, and six plates.

1891. "Descriptions of some new or previously unrecorded Species of Fossils from the Devonian Rocks of Manitoba": idem, vol. viii, sect. iv, pp. 93–110, with seven plates.

Geological Survey of Canada. Contributions to Canadian Palæontology, Vol. I, Part 3.—(5) "The Fossils of the Devonian Rocks of the Mackenzie River Basin": Montreal, pp. 197–253, with six plates.

"Descriptions of four New Species of Fossils from the Silurian Rocks of the South-Eastern portion of the District of Saskatchewan": Canad. Rec. Sci., vol. iv, p. 293, with one plate.

"Description of a New Species of Panenka from the Corniferous Limestone of Ontario": idem, p. 401, with one plate.

"Note on the occurrence of Paucispiral Opercula of Gasteropoda in the Guelph Formation of Ontario": idem, p. 404.

1892. "The Orthoceratidæ of the Trenton Limestone of Manitoba": Trans. Royal Soc. Can., vol. ix, sect. iv, pp. 77–90, with seven plates.

"Description of a New Genus and Species of Phyllocarid Crustacea from the Middle Cambrian of Mount Stephen, B.C.": Canad. Rec. Sci., vol. v, p. 205.

Geological Survey of Canada. Contributions to Canadian Palæontology, Vol. I, Part 4.—(6) "The Fossils of the Devonian Rocks of the Islands, Shores, or immediate vicinity of Lakes Manitoba and Winnipegosis": Ottawa, pp. 255–359, with fifteen plates.

1893. "Notes on the Ammonites of the Cretaceous Rocks of the District of Athabasca, with descriptions of four new species": Trans. Royal Soc. Can., vol. x, sect. iv, pp. 111–121, with four plates.

"Notes on the Gasteropoda of the Trenton Limestone of Manitoba," with a description of one new species: Canad. Rec. Sci., vol. v, p. 317, with two text-figures.

"Descriptions of two New Species of Ammonites from the Cretaceous Rocks of the Queen Charlotte Islands": idem, vol. vi, p. 441, with one plate.

1894. "Notes on some Marine Invertebrata from the Coast of British Columbia": Ottawa Naturalist, vol. vii, p. 133, with one plate.

"The Cretaceous System in Canada" (Presidential Address in Section IV): Trans. Royal Soc. Can., vol. xi, sect. iv, pp. 3–16.

"The Recent Discovery of large Unio-like Shells in the Coal-measures at the South Joggins, N.S.": idem, pp. 21–24, with one plate.

1895. "Notes on Recent Canadian Unionidæ": Canad. Rec. Sci., vol. vi, p. 250.

"Additional Notes on Recent Canadian Unionidæ": idem, p. 365.

"Notes on some Fossils from the Cretaceous Rocks of British Columbia, with descriptions of two species that appear to be new": ibid., p. 313.

"Descriptions of eight New Species of Fossils from the (Galena) Trenton Limestones of Lake Winnipeg and the Red River Valley": ibid., p. 387.

Geological Survey of Canada. Palæozoic Fossils, Vol. III, Part 2.—(2) "Revision of the Fauna of the Guelph Formation of Ontario, with description of a few new species"; (3) "Systematic List, with references, of the Fossils of the Hudson River or Cincinnati Formation at Stony Mountain, Manitoba": Ottawa, pp. 45–128, with seven plates.

1896. "Notes on some of the Cretaceous Fossils collected during Captain Palliser's Explorations in British North America in 1857–60": Trans. Royal Soc. Can., ser. II, vol. i, sect. iv, p. 101.

"On some Fossils from the Nanaimo Group of the Vancouver Cretaceous": idem, p. 119.

"Note on the occurrence of *Primnoa reseda* on the Coast of British Columbia": ibid., p. 135.

"Canadian Stromatoporoids": Canad. Rec. Sci., vol. vii, p. 129.

1897. Geological Survey of Canada. Palæozoic Fossils, Vol. III, Part 3.—(4) "The Fossils of the Galena-Trenton and Black River Formations of Lake Winnipeg and its vicinity": Ottawa, pp. 129–242, with seven plates and thirteen text-figures.

"Description of a New Genus and Species of Cystideans from the Trenton Limestone at Ottawa": Canad. Rec. Sci., vol. vii, p. 287.

1898. "Postscript to a 'Description of a New Genus and Species of Cystideans from the Trenton Limestone at Ottawa'": idem, p. 395.
"On some Remains of a Sepia-like Cuttle-fish from the Cretaceous Rocks of the South Saskatchewan": ibid., p. 459.
"Note on a Fish Tooth from the Upper Arisaig Series of Nova Scotia": ibid., p. 461.
"On some Fossil Cephalopoda in the Museum of the Geological Survey of Canada, with descriptions of eight species that appear to be new": Ottawa Nat., vol. xii, p. 116.
Geological Survey of Canada. Contributions to Canadian Palæontology, Vol. I, Part 5, and last.—(7) "On some additional or imperfectly understood Fossils from the Hamilton Formation of Ontario, with a revised list of the species therefrom." (8) Appendix: Revision of the nomenclature of some of the species described or enumerated in previous parts of this volume, and additional notes on others, necessitated by the progress of palæontological research. Ottawa, pp. 361–436, with three plates and five text-figures; also with general title-page, letter of transmittal, and index.

1899. "Recent Discovery of Rocks of the Age of the Trenton Formation at Akpatok Island, Ungava Bay, Ungava": Amer. Journ. Sci., ser. iv, vol. vii, p. 433.
"The Devonian System in Canada."—Address of the Vice-President and Chairman of Section E (Geology and Geography) of the American Association for the Advancement of Science, at its forty-eighth annual meeting, held at Columbus, Ohio, in 1899, and published in its Proceedings for that year.

1900. Geological Survey of Canada. Mesozoic Fossils, Vol. I, Part 4.—(4) "On some additional or imperfectly understood Fossils from the Cretaceous Rocks of the Queen Charlotte Islands, with a revised list of the species from these rocks": Ottawa, pp. 263–307, with two text-figures and seven plates.

1901. "Description of a New Species of *Unio* from the Cretaceous Rocks of the Nanaimo Coal Field, V.I.": Ottawa Nat., vol. xiv, p. 177.
"Notes on some Land and Fresh-water Mollusca from Fort Chimo, Ungava Bay, Ungava": idem, p. 221.
"Note on a supposed New Species of *Lytoceras* from the Cretaceous Rocks at Denman Island, in the Strait of Georgia": idem, vol. xv, p. 31.
Geological Survey of Canada. "Catalogue of the Marine Invertebrata of Eastern Canada": Ottawa, pp. 1–272, with two figures in text.

1902. "Bibliography of Canadian Zoology for 1900": Trans. Royal Soc. Can., ser. ii, vol. vii, sect. iv, p. 87.
"The Golden Eagle (*Aquila chrysaetos*) in Ontario": Ottawa Nat., vol. xv, p. 249.
"On the genus *Panenka*, Barrande," with a description of a second species of that genus from the Devonian rocks of Ontario: idem, p. 263.
"Note on the Nesting of the Northern Raven (*Corvus corax principalis*) in Canada": ibid., vol. xvi, p. 86.
"Notes on some Fresh-water and Land Shells from Keewatin, Northern Ontario, and British Columbia": ibid., p. 91.
"Additions to the Geological Survey's Collection of Eggs in June, 1902": ibid., p. 96.
"On the Genus *Trimerella*," with descriptions of two supposed new species of that genus from the Silurian rocks of Keewatin: ibid., p. 139.
"A Canadian Two-headed Snake": ibid., p. 148.
"The Acadian Sharp-tailed Sparrow (*Ammodramus caudacutus subvirgatus*)": ibid., p. 162.

1903. "Description of a Fossil Cyrena from Alberta": ibid., p. 231.
"Crania of Extinct Bisons from the Klondike Creek Gravels": ibid., p. 240.
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"The Canadian Species of *Trocholites*": idem, vol. xviii, p. 13.

"A White Pelican at Manotick": ibid., p. 71.

"The Brown Pelican on Cape Breton Island": ibid., p. 108.

"Description of a New Genus and Species of Rugose Corals from the Silurian Rocks of Manitoba": ibid., p. 113.

"*Uintacrinus* and *Homaster* in the Vancouver Cretaceous": Amer. Journ. Sci., ser. IV, vol. xviii, p. 287.

"Preliminary List of Fossils from the Silurian (Upper Silurian) Rocks of the Ekwan River and Sutton Mill Lakes, Keewatin, collected by D. B. Dowling in 1901, with descriptions of such species as appear to be new."—Appendix I to Mr. Dowling's Report: Geol. Surv. Can., Ann. Rep., vol. xiv, part F, pp. 38–39.

1905. "Notes on the Apical End of the Siphuncle in some Canadian Endoceratidæ, with descriptions of two supposed new species of *Nanno*": American Geologist, vol. xxxv, p. 23.

"Bibliography of Canadian Zoology for 1903, exclusive of Entomology": Trans. Royal Soc. Can., ser. II, vol. x, sect. iv, pp. 161–166.

"Notes on some Fresh-water Shells from the Yukon Territory": The Nautilus, vol. xix, p. 1; and Ottawa Nat., vol. xix, p. 63.

"Lists of a few Species of Land and Fresh-water Shells from the immediate vicinity of James Bay, Hudson Bay": The Nautilus, vol. xix, p. 4; and Ottawa Nat., vol. xix, p. 66.

"The Banded Pocket-Mouse (*Perognathus fasciatus*)": Ottawa Nat., vol. xix; p. 69.

"List of Land and Fresh-water Shells from the District of Keewatin, collected by W. McInnes in 1904": Geol. Surv. Can., Summary Rep. 1904, p. 160.

"Description of a New Species of *Goniobasis* from British Columbia": The Nautilus, vol. xix, p. 61.

"Some New Localities for Canadian Land and Fresh-water Shells": Ottawa Nat., vol. xix, p. 169.

1906. "Some New Canadian Records for Gyrfalcons": idem, p. 208.

"Bibliography of Canadian Zoology for 1904, exclusive of Entomology": Trans. Royal Soc. Can., ser. II, vol. xi, sect. iv, p. 65. But, separates were issued in 1905.

Geological Survey of Canada. Palæozoic Fossils, Vol. III, Part 4, and last.—(5) "The Fossils of the Silurian (Upper Silurian) Rocks of Keewatin, Manitoba, the North-Eastern Shore of Lake Winnipegosis, and the lower Saskatchewan River"; (6) "The Canadian Species of *Plectoceras* and *Barrandeoceras*"; (7) "Illustrations of seven species of Fossils from the Cambrian, Cambro-Silurian, and Devonian Rocks of Canada"; (8) "Revised List of the Fossils of the Guelph Formation of Ontario." With Appendix, consisting of a list of errata and an index to the volume. Ottawa, pp. 243–352, with twenty plates and eight text-figures.

II.—On two Specimens of *Ichthyosaurus* showing contained Embryos.

By A. Smith Woodward, LL.D., F.R.S.

(PLATE XXIV.)

FOR many years it has been known that *Ichthyosaurus* was a viviparous reptile,[1] but until quite recently the British Museum has not possessed a specimen with contained embryos. This deficiency has now been supplied by the acquisition of two fine skeletons, which are worthy of special notice.

The first of these newly acquired specimens (Pl. XXIV, Fig. 1) is of much historic interest, because it was discovered and described so long ago as 1846 by the late Dr. J. Chaning Pearce, a well-known pioneer in Palæontology.[2] It was obtained from the Lower Lias of Somersetshire, and appears to belong to the species *I. communis*. The skeleton is nearly complete, and is exposed from the right side, though partly from below. The ribs and paddles of the right side are displaced upwards; and the tail is dislocated, though clearly exhibiting the downward flexure of its terminal portion. The single embryo, as described by Chaning Pearce, lies between the two sides of the pelvis, crushed on the three hindmost ribs. Its head points backwards, but is flattened by crushing, and does not show any structural details. The vertebral centra are small biconcave discs of spongy bone, not arranged in continuous series but somewhat scattered. The head of the embryo, so far as preserved, measures 0·04 m. in length, while the remains of the trunk extend for another length of 0·105 m. The total length of the parent is about 2·25 m., that of the head being 0·5 m. Although its precise dimensions cannot be determined, the embryo in this individual is therefore relatively smaller than in the other known specimens.

The second Ichthyosaur with embryos received by the British Museum (Pl. XXIV, Fig. 2) was obtained from the Upper Lias of Holzmaden, Würtemberg, and is referable to *I. quadriscissus*, which has been provisionally identified by Mr. Lydekker with *I. acutirostris*.[3] This is the species to which all the best specimens displaying embryos belong. The skeleton, which measures about 2·4 m. in length, is well preserved and exposed from the right side, the right ribs only being displaced upwards. The black contents of the stomach are clearly shown in the lower part of the abdominal region. There are remains of at least six embryos within the ribs, but some of them have been displaced forwards, either by *post-mortem* crushing or by escape into the body-cavity during life (as happens occasionally in

[1] H. G. Seeley, "Report on the Mode of Reproduction of certain species of *Ichthyosaurus* from the Lias of England and Würtemberg": Rep. Brit. Assoc., 1880 (1881), pp. 68–76, pl. i. E. Fraas, "Die Ichthyosaurier der süddeutschen Trias- und Jura-Ablagerungen" (Tübingen, 1891), p. 34, pl. iv, fig. 2.

[2] J. Chaning Pearce, "Notice of what appears to be the Embryo of an *Ichthyosaurus* in the Pelvic Cavity of *Ichthyosaurus (communis ?)*": Ann. & Mag. Nat. Hist., vol. xvii (1846), pp. 44–46.

[3] R. Lydekker; "Catal. Foss. Rept. B.M.," pt. ii (1889), p. 73.

viviparous lizards [1]). All the embryos are of the same size, relatively large, and with the proportions of the skull similar to those of the parent's skull. The snout in every case points forwards. The embryonic skull is best displayed in an individual far forwards within the ribs above the vertebral column, where it is shown in direct side-view. The rostrum here is crushed on the heads of the ribs, and bears the impress of the latter, indicating the soft nature of its bone-tissue. Behind the skull is part of the vertebral column in position, with some of the ribs, and apparently the ossified portions of the coracoids. A second good embryonic skull occurs slightly further back just below the vertebræ of the parent, and is interesting as displaying the teeth in the form of thin, hollow cones. At the hinder end of its mandible is seen the ossified shaft of a humerus. Below and in front of this second specimen are three more imperfect embryonic skulls, only partially exposed, the lowest somewhat obscured by the black stomach-contents. Behind the middle specimen there occurs part of the vertebral column with ribs; and some of the small vertebral centra appear to exhibit the facettes for neural arches. The sixth embryo is indicated only by short chains of biconcave vertebral centra scattered in the region of the pelvis. The limbs are not shown in any embryo within the body, but there is an embryonic fore-paddle 0·036 m. in length near the displaced ribs above the head. The bones in this paddle are not completely ossified, but so far as preserved are in their natural position. The radius is half as long as the ossified part of the humerus, whereas in the adult paddle the same bone measures only one-third the length of the humerus. The length of the best embryonic skull is about 0·19 m., while that of the skull of the parent is not more than 0·5 m.

The largest number of embryos hitherto observed in one individual of *Ichthyosaurus acutirostris* (*quadriscissus*) is seven [2]; and it is interesting to note that in each recorded case of more than one contained embryo, the young are always directed with the snout forwards. A single embryo in the middle of one specimen in the Stuttgart Museum is also turned forwards; but in each known instance in which the single embryo is so far back as the pelvis, the snout is directed backwards.[3] The specimens recently acquired by the British Museum conform to this rule.

EXPLANATION OF PLATE XXIV.

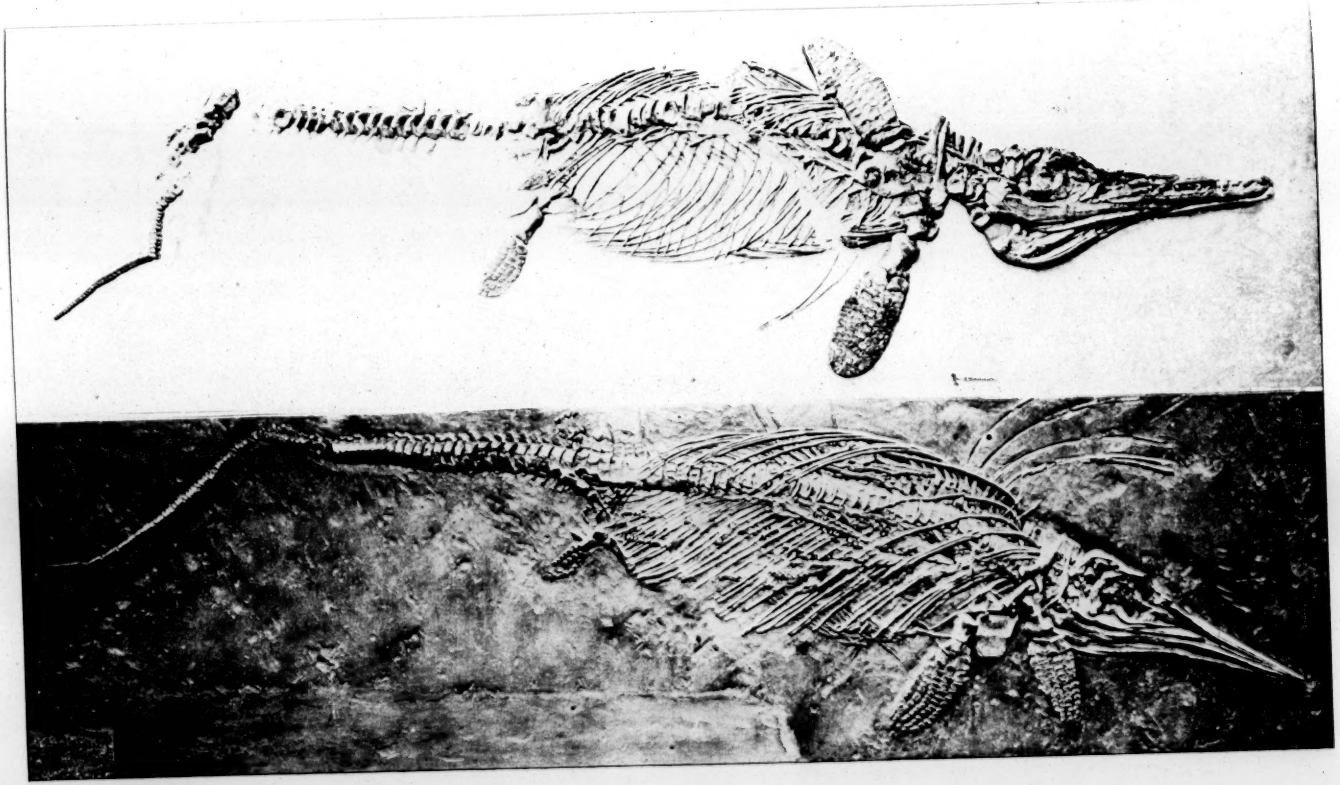
Fig. 1.—*Ichthyosaurus communis*, Conybeare; skeleton showing very small embryo in the pelvic region. About one-fourteenth nat. size. Lower Lias: Somersetshire. [Chaning Pearce Collection, British Museum, No. R. 3372.]

Fig. 2.—*Ichthyosaurus acutirostris*, Owen (*quadriscissus*, Quenstedt); skeleton showing remains of six large embryos within the ribs. About one-fourteenth nat. size. Upper Lias: Holzmaden, Würtemberg. [British Museum, No. R. 3300.]

[1] F. E. Beddard, "Note on an apparently Abnormal Position of the 'Brephos' within the Body of a Skink (*Chalcides lineatus*)": Proc. Zool. Soc., 1904, vol. ii, pp. 145–147, text-fig. 25.

[2] E. Fraas, op. cit. H. F. Osborn, "Ichthyosaurs": Century Magazine, vol. lxix (1905), pp. 414–422, text-figs. 1–6.

[3] See Seeley and Fraas; also A. Gaudry, "Les Enchaînements du Monde Animal—Fossiles Secondaires" (1890), p. 185, fig. 275.



Two specimens of *Ichthyosaurus* showing contained Embryos:

1. *Ichthyosaurus communis*, Conybeare; Lower Lias, Somersetshire.
2. *Ichthyosaurus acutirostris*, Owen; Upper Lias, Wirtemberg.

III.—The Carboniferous Succession below the Coal-Measures in North Shropshire, Denbighshire, and Flintshire.

By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S., and John T. Stobbs, F.G.S.

(*Continued from the September Number, p.* 400.)

(xxviii) The road from Llanarmon to Graianryd practically traverses the whole limestone sequence. The following fossils were obtained from the quarry about half a mile north of Llanarmon, by the roadside, where some 20–30 feet of limestone was exposed:—

Cyathophyllum Murchisoni, E. & H.
Dibunophyllum sp.
Syringopora sp.
Athyris expansa, Phill.
Chonetes aff. *comoides* (J. Sow.). (Like the mutation in D_1 of the Bristol area.)
Martinia glabra (Mart.).
Productus Cora, D'Orb.
P. hemisphericus, J. Sow.
P. punctatus (Mart.).

In the quarry opposite the Stag Inn, east of Llanarmon, limestone beds with *Productus giganteus* (Mart.) are well exposed.

A few hundred yards further east there is a quarry in a farmyard with thin rubbly and bedded limestones. Here *Productus giganteus* (Mart.) occurs in several bands, with *Cyathophyllum* and *Amplexizaphrentis*. A little further up the wood occur dark thin-bedded limestones, with bands of *Productus hemisphericus* (J. Sow.), *P. giganteus* (Mart.), and *Lithostrotion irregulare*, Phill., on which lie yellow calcareous shales with *Productus giganteus* (Mart.).

(xxix) The next section is at Graianryd, which shows soft yellow sandstone, with occasional quartz pebbles and pebbly grit. The sandstone is very fossiliferous, and contains—

Camarotœchia trilatera (De Kon.).
Productus longispinus, Sow.
Spirifer bisulcatus, Sow.
Fragment of a large Nautiloid.
Fish-teeth (fragments ? *Psephodus*).

This bed, evidently, is the equivalent of the coarse pebbly grit and soft sandstone with fish-teeth seen at Gwernymynydd (*ante*, p. 398).

(xxx) Half a mile south-east of Graianryd, at Pant-y-terwyn, on the west of the road, is a fine quarry in cherts, which evidently succeed conformably the calcareous pebble grit, and we there get the following sequence:—

Cherts (of Pant-y-terwyn).
Calcareous pebbly grit (of Graianryd).
Carboniferous Limestone, with *Productus giganteus* (Mart.) near the Stag Inn.

Some of the latter series, however, are not exposed. This sequence agrees well with that at Gwernymynydd, and shows the transition from the Cherty Limestone near Pentre Halkyn (p. 396), through the calcareous grits of Hendre and Gwernymynydd, to the pebble grit of Graianryd. It is this part of the series that is represented by the lower part of the Cefn-y-Fedw Series of G. H. Morton.[1]

(xxxi) The neighbourhood of Minera affords sections of practically the whole of the Carboniferous System up to the horizon of

[1] G. H. Morton: "The Carboniferous Limestone and Cefn-y-Fedw Sandstone of the Country between Llanymynech and Minera," 1879.

the Gwespyr Sandstone, whose representative is exposed in a quarry near Berwig Station. The beds here resemble closely, both in colour and in petrological character, the sandstones and grits of Gwespyr, and contain many fragments of plants and woody débris. At the top of the hill at Pen-y-Bwlch are a series of strong cherts, which crop out behind the houses in the village. Morton mentions[1] that the sandy limestones and white sandstones with quartz pebbles, about 170 feet thick, are to be seen at Craig Mawr and Craig Fechan. At Minera the limestones rest directly on the Bala Beds, with a thin, patchy basement conglomerate, and the junction can be seen and traced for some distance in the bed of the stream which runs from Ty hir through the quarries called the Clywedog. The lower beds of limestone are crammed full of *Daviesiella Llangollensis* (Dav.), a very easily recognised species, even in section, on account of the large comparative thickness of the pedicle valve. This species we consider to have a time value in North Wales, a fact which Morton seems to have recognised, for it always occurs in his lists of fossils from the Lower Brown Limestone. In the case of Minera, however, Morton did not recognise the existence of the Lower Brown Limestone, but refers the lower beds (160 feet) to his Upper White Limestone division. From a colour point of view he is certainly correct, since there is no *brown* limestone in this locality, but the presence of large numbers of *D. Llangollensis*—evidently the maximum of this fossil—seems to us to be conclusive evidence of the contemporaneity of these beds with others containing the same fossil. Beds immediately above the *Daviesiella* beds contain abundance of *Seminula* aff. *ficoides*, giving a similar palæontological succession to that at Llandulas.

Morton estimates the whole limestone series at Minera as 436 feet thick, and *D. Llangollensis* is confined to the lowest few feet of the series. Fossils were very rare indeed in the succeeding 350 feet of limestone. Quarrymen said that specimens occurred only occasionally, and we were not able to find any in the loose blocks about the quarry.

On the other hand, the upper beds of limestone east of the large quarries, exposed successively in abandoned quarries and outcrops on the hill, contain the typical fossils of that zone, viz. :—

Cyathophyllum cf. *regium*, Phill.
Lithostrotion irregulare (Phill.).
L. junceum (Flem.).
L. Portlocki (Bronn).
Lonsdaleia rugosa, M'Coy.
Productus giganteus (Mart.).
And many beds of crinoids.

In this series the limestones become cherty, and the beds assume the lithological character of the upper limestones on Halkyn Mountain.

Morton gives a much longer list of fossils from the Upper Grey Limestone of Minera than we collected—a list which we are prepared to accept, with three exceptions, because we know the species enumerated occur universally at this horizon in the counties of Flint and Denbigh. The exceptions are—(1) *Athyris Royssii*, which should probably stand for *A. planosulcata*, Phill.; (2) *Aviculopecten*

[1] Op. sup. cit., p. 71.

micropterus, which is probably *A. dissimilis* (Flem.); and (3) *Zaphrentis cylindrica*, which is either *Campophyllum* or *Amplexi-zaphrentis*.

The *Productus giganteus* beds are succeeded by yellowish sandy limestones and a pebbly grit, and at the top of the hill are the strong cherts of Pen-y-Bwlch. Morton estimates the Carboniferous Limestone of the Eglwyseg ridge at 1,200 feet, which he subdivided as under:—

	feet.
Upper Grey Limestone	300
Upper White Limestone...	300
Lower White Limestone	120
Lower Brown Limestone	480
	1200

These beds are all exposed either in the fine escarpment of the Eglwyseg ridge or the Trevor and Bronheulog quarries, and rest in places on a basement of red conglomerate, which is to be seen near Dibren Uchaf and at the foot of Craig-yr-ogof. The brown limestones at the base of the limestone series contain plant-remains in a fragmentary state. The most abundant and characteristic fossil is *Daviesiella Llangollensis*. The number of fossil species is not large, but individuals are fairly numerous, and we collected the following:—

Alveolites septosa (Flem.).
Syringopora sp.
Athyris planosulcata, Phill.
Daviesiella Llangollensis (Dar. sp.).
Productus Cora, D'Orb.
Fragments of a giganteid *Productus*.
Reticularia lineata (Mart.).
Bellerophon sp.
A Nautiloid shell. (Fragmentary.)
Euomphalus Dionysii, Goldfuss.
Murchisonia Kendalensis, M'Coy (Donald).
Pleurotomaria. (Large globular species.)

A list which is almost identical with that of G. H. Morton.

The fossils all seem to come from the lower part of the series. They are not very common in the whiter beds above the Brown Limestone, but we obtained the following:—

Cyathophyllum Murchisoni, E. & H.
Dibunophyllum sp.
Lithostrotion Martini, E. & H.
Syringopora sp.
Athyris expansa, Phill.
Chonetes papilionacea, Phill. (Flattened form.)
Productus Cora, D'Orb.
P. giganteus (Mart.).
Edmondia sulcata (Phill.).
Sanguinolites striatolamellosus, De Kon.

Morton states that he found *Lonsdaleia duplicata* (Mart.) and *L. rugosa*, M'Coy, *Lithostrotion irregulare* (Phill.), *L. junceum* (Flem.), and *L. Portlocki* (Bronn) at this horizon. In the appendix to his larger work, "The Geology of the Country round Liverpool," p. 318, he says: "Of the 37 species in the Upper Grey Limestone of Flintshire there is only one which seems peculiar to it, and that is *Lonsdaleia rugosa*, but it occurs in the Middle White Limestone of Llangollen." We find that the range of this fossil includes a portion of the Middle White Limestone of Morton.

Mistakes might easily occur at the Eglwyseg ridge unless the specimen were actually taken from the rocks *in situ*, for slopes of talus extend largely from the top to the base of the hill, and fossils from the upper beds are brought down in this way and mingle with those from the lower beds.

Still higher in the series, Morton's 'Upper White Limestone' has practically the same fauna as the beds immediately below, and hence no palæontological line can be drawn between them.

The 'Upper Grey Limestone' of Morton is much richer in species than the beds below, and is characterised by the abundance of giganteid *Producti* and *Spirifer bisulcatus*, Sow. Morton's list is a large one, containing 98 species of Brachiopods, Lamellibranchs, Corals, Echinoderms, Polyzoa, and fishes.[1] The Lamellibranchs passed through the hands of one of the writers, and were determined by him as—

Conocardium aliforme, Sow.
Edmondia sulcata (Phill.).
Leiopteria sp.
Lithodomus lingualis (Phill.).
Pinna flabelliformis, Mart.
Protoschizodus impressus, De Kon.
Sanguinolites clavatus, R. Eth., jun.

With regard to the rest of the fauna, it has a distinctly Viséan facies, and indicates the upper part of the Carboniferous Limestone. We collected the following Corals *in sitû* from a bed nearly at the top of the Ty-nant ravine below the yellow calcareous shales. Corals are present in great abundance:—

Cyathophyllum cf. *regium*, Phill.
Dibunophyllum sp.
Lithostrotion ensifer, E. & H.
L. irregulare (Phill.).
L. junceum (Flem.).
L. Portlocki (Bronn).
Lonsdaleia floriformis, Lonsd.
L. rugosa, M'Coy.
Phillipsastræa radiata, E. & H.
Syringopora sp.

Morton also quotes, amongst others, *Aulophyllum*, *Axophyllum*, several species of *Clisiophyllum*, *Cyclophyllum fungites*, *Koninckophyllum*, *Zaphrentis Bowerbanki*, *Z. cylindrica*, and *Z. Enniskilleni*—all of which, with the exception of *Zaphrentis cylindrica* (= *Caninia*), we should expect to occur at this horizon.

The horizon of this coral band all over North Wales is definite, and marks out a time-zone of great importance, not only locally, but one which can be perfectly correlated with the D_2 zone of the Bristol and Mendip areas, so ably worked out by Dr. A. Vaughan.[2]

In the Eglwyseg ridge the coral zone is succeeded by yellowish calcareous shales, which in turn are overlain by a whitish limestone with giganteid *Producti* and crinoids. This bed, we suppose, is the top of Morton's Carboniferous Limestone Series, but it may possibly belong to the lowest beds of his Cefn-y-Fedw Sandstone, which he terms 'the sandy limestone.' Above this limestone Morton describes "a bed of dark grey limestone, 11 feet thick . . . . It contains numerous encrinite stems with *Productus giganteus*, *P. semireticulatus*, and *P. Cora*, and is succeeded by yellow flaggy sandstones containing annelid tracks." The fact that *P. giganteus* occurs here militates against any subdivision at this horizon. If one feature comes out strongly all over the British Isles and Belgium it is that *P. giganteus* characterises the upper beds of the Carboniferous Limestone Series, and that the faunal change only comes on when this shell disappears, whilst from the stratigraphical

[1] G. H. Morton: "Carboniferous Limestone of Anglesey," pp. 52, 64.
[2] A. Vaughan: Q.J.G.S., vol. lxi, pp. 181–307.

point of view this *P. giganteus* bed is succeeded by the pebbly conglomerate—a bed which can be traced in the sequence from Gwernymynydd to Llangollen. It is interesting to note that the upper beds of limestone at Castleton, Derbyshire, contain occasional quartz pebbles.

(xxxii) The outlier of Carboniferous Limestone at Corwen was also visited by one of us. The quarry exposes the upper beds of the limestone, and is altogether in the zone of *Lonsdaleia*, the upper *Dibunophyllum* zone, but it is impossible to ascertain the thickness of the beds below those that are quarried. At the top there are thick, well-bedded limestones, beneath which are shales with nodules in layers and thin limestones. The beds worked in the quarries are estimated by Morton at 80 feet. The upper limestones contain—

Lithostrotion Portlocki (Bronn).
Syringopora sp.
Rhynchonella pleurodon (Phill.).
Martinia glabra (Mart.).
Productus giganteus (Mart.).
P. punctatus (Mart.).

The 10 feet of black shaly beds below the limestone are full of corals, and contain—

Alveolites septosa (Flem.).
Cyathophyllum cf. *regium*, Phill.
Dibunophyllum sp.
Lithostrotion irregulare (Phill.).
L. junceum (Flem.).
L. Portlocki (Bronn).
Lonsdaleia rugosa, M'Coy. (Very abundant.)
Phillipsastræa radiata, E. & H. (Common.)
Seminula ambigua (Sow.).

(xxxiii) South of the Dee the limestone outcrops almost continuously for 12 miles from Fron-y-cysyllte to Llanymynech, the outcrop varying from a half to one mile in width. It is of interest that at Fron, according to Morton, only the upper moiety of the series, as exposed in the Eglwyseg ridge, is present, demonstrating the fact that the Wenlock beds in this position were not submerged till later on in Carboniferous time. This also seems to be borne out by the various sections of limestone at Bron-y-garth, Craignant, Llawnt, Porth-y-waen, and Llanymynech. At the latter place Morton estimated the whole limestone series to be 450 feet thick, as against 1,200 feet at Ty-nant, near Llangollen.

Morton[1] shows the following variation in thickness in a distance of 4 miles from west to east :—

Ty-nant.	Tan-y-castell.	Trevor Rocks.	Bronheulog.	Fron.
1,200 feet.	1,025 feet.	607 feet.	295 feet.	115 feet.

And as the upper part of the series is similar in each locality, it follows that the floor on which the limestone was deposited was very uneven, and a considerable overlap of the upper beds occurs locally and in a definite manner from south to north.

(xxxiv) A traverse from Sweeney Mountain, through Treflach Wood Quarries, gives a fairly complete view of the sequence in this area. The old tramway which afforded the section of Cefn-y-Fedw Sandstone published by D. C. Davies[2] and by G. H. Morton[3] has now unfortunately largely disappeared, but many of the beds can

[1] G. H. Morton: op. sup. cit., p. 39.
[2] Geol. Mag., Vol. XII (1870), p. 69.
[3] G. H. Morton: op. sup. cit., p. 93, pl. vi.

still be seen. Morton estimated the thickness of these beds at about 500 feet. Several quarries still exist close to the tramway, showing sandstones of various shades of colour. The highest bed, called by Morton the Sweeney Mountain Sandstone, is a very white and soft rock, in which are traces of fossils, fragments of Brachiopoda, and an obscure coral. Below this bed are other sandstones, pink and red in colour, containing marine fossils—

Actinoceras giganteum, Sow. (*Fide* Morton.)
Productus sp.
Schizophoria resupinata (Mart.).

Still lower comes a hard white sandstone estimated at 70 feet, resting on 150 feet of soft red sandstone, which is fossiliferous in places.

The following section is to be seen at the Treflach Wood Quarries :—

5. Pebbly grit, 1 foot.
4. Soft red sandstone, 6–8 feet.
   Gap, hollow ground, grassed over.
3. Thin beds of limestone, 20 feet.
2. Limestone and shale, 10–15 feet (the limestones varying from 6 in. to 1 ft. thick).
1. Dark limestones, well bedded.

Thin limestones (2) contain—

Campophyllum aff. *Murchisoni*, E. & H.
Cyathophyllum cf. *regium*, Phill.
Productus giganteus (Mart.).

Thin beds of limestone (3) contain—

Alveolites septosa (Flem.).
Campophyllum aff. *Murchisoni*, E. & H.
Dibunophyllum sp.
Lithostrotion irregulare (Phill.).
L. junceum (Flem.).
Lonsdaleia floriformis (Flem.).
Productus giganteus (Mart.).

The same series with a similar fauna occur at Dolgoch, a little more than a mile S.S.W. of the last section.

(xxxv) The sandstones of the Cefn-y-Fedw Series at Selattyn, Oswestry Racecourse, and Sweeney Mountain are fossiliferous, and the following species were obtained, many of which have been mentioned by Davies and Morton :—

Rhynchonella pleurodon (Phill.).
Orthotetes crenistria (Phill.).
Productus Cora, D'Orb.
P. costatus, J. Sow.
P. punctatus (Mart.).
Schizophoria resupinata (Mart.).
Spirifer sp.
Edmondia Goldfussi, De Kon.
E. sulcata (Phill.).
Parallelodon Geinitzi, De Kon.
P. semicostatus (?).
Pinna flabelliformis, Mart.
Protoschizodus æquilateralis (M'Coy).
Tellinomorpha cuneiformis, Hind.
Pleurotomaria sp.

(*b*) *Pendleside Series.*

The best exposure showing the conformable relation of the Pendleside Series to the underlying cherts is seen at the Grange Quarry, Holloway (lat. 53° 16′ 35″ N., long. 3° 14′ 25″ W.), about a mile north of Holywell. At the entrance to this quarry the black shales and thin platy black limestones are deposited directly on the

cherts, which at this locality are about 25 feet thick and dip eastwards at 20°. The cherts in turn rest on the uppermost beds of limestone, so that the succession here is uninterrupted, and presents no complications. In the Pendleside limestones, which are rarely more than 2 inches in thickness, the following fossils were found :—

Posidonomya membranacea, M'Coy. (Abundant.)
Acrolepis Hopkinsi (M'Coy). (Not rare.)

A small portion of the same horizon, consisting of black shales and thin black limestones, has escaped denudation, and may be observed resting conformably on about 70 feet of black cherts (the full section of which was not exposed) near the foot of the hill at Pentre, near Gronant (see *supra*, p. 393) (lat. 53° 20′ 20″ N., long. 3° 21′ 30″ W.). At the east side of the entrance to this quarry we have the following section :—

3. Thin, platy black limestones.
2. Soft, laminated black shales, 1 ft. 6 in.
1. Black cherts in beds from 1 in. to 3 in. in thickness.

The black limestones at the top of the section have the characteristic 'sawn edges' referred to later (p. 452). The black shales yielded the following list :—

Posidonomya Becheri, Bronn. (Rare.) Plant-remains. (Indeterminable.)
Cladodus. (Teeth.) *Acrolepis Hopkinsi*.

Beds identical with these are exposed on the west side of the road at and below the well near Gronant Mine (lat. 53° 20′ 7″ N., long. 3° 21′ W.), where they are found to dip north at 13°.

Succeeding these beds in order of deposition is the following section of a large quarry in the wood facing to the south the Nant Hall Hotel, near Prestatyn (lat. 53° 19′ 50″ N., long. 3° 23′ 10″ W.) :—

LADY MCLAREN'S QUARRY.

		ft.	in.	
16.	Shales and limestone	12	0	
15.	Shale	1	0	*Pterinopecten papyraceus* (Sow.). (Abundant.)
14.	Fissile limestone	2	0	*Pterinopecten papyraceus* (Sow.).
13.	Paper shales	0	4	
12.	Platy black limestones and shales	1	0	*Productus hemisphericus*, J. Sow. ; Crinoids.
11.	Shale	0	3	
10.	Black limestone	0	3	
9.	Shell bed (limestone)	1	6	
8.	Limestone and shales	2	6	
7.	Shales	0	5	
6.	Limestone	1	4	
5.	Shales	0	4	
4.	Thin platy limestones	1	6	*Pterinopecten papyraceus*, *Orbiculoidea nitida*.
3.	Fissile black shales	1	2	*Glyphioceras* sp., *Amusium* sp., plant-remains.
2.	Black limestone	1	10	*Phillipsia Polleni*, *Cyathaxonia*.
1.	Shale	2	0+	*Amplexi-zaphrentis*, *Acrolepis*, *Wilsonia*, *Elonichthys* (scale), large plates.

In addition to the fossils given in the above section, No. 9 (shell bed) contains *Amplexi-zaphrentis* sp., *Productus giganteus* (Mart.), *P. Cora*, D'Orb., *P. hemisphericus*, J. Sow., and *Spirifer bisulcatus*, Sow. No. 13 (paper shales) contains *Pterinopecten papyraceus* (Sow.) (in abundance), Goniatites, and plant-remains. No. 16 (shales and limestones) contains *Posidonomya Becheri*, Bronn (common), *Orthoceras* sp., and *Dithyrocaris* sp.

In the same wood, not many yards from the last section and resting immediately above it, is an excellent exposure of the thinly bedded black limestones, whose upper and lower surfaces are remarkably planar. When struck by a hammer they produce a sonorous metallic 'chink.' Their vertical joints, as they are seen passing through all the platy limestones in contact, have the appearance of the sawn edges of a pile of boards. These black limestones of this horizon we will refer to as 'Teilia Beds,' from the fact of their occurrence at a farm called Teilia, near Gwaen-ys-gor. At the quarry already mentioned near Nant Hall Hotel the beds dip to the west at 5°, and the following list was obtained :—

Posidonomya Becheri, Bronn. (Common.)
Goniatites.
Orthoceras sp.
Dithyrocaris sp.
Plant-remains.

The same beds are to be found in a quarry under the road leading from Prestatyn to Gwaen-ys-gor (lat. 53° 19′ 40″ N., long. 3° 23′ 20″ W.), where they are faulted to the east against beds of Carboniferous Limestone (see p. 392). The fault can be traced close to the road, and its downthrow to the east is estimated to be at least 80 feet. In this quarry the following fossils were fairly common :—

Productus plicatilis, Sow.
Posidonomya Becheri, Bronn.
Orthoceras sp.
Plants.

Lower down the hillside and cropping out midway between the first and second bends in the road from Prestatyn (lat. 53° 19′ 45″ N., long. 3° 23′ 25″ W.), the underlying limestone shales were observed dipping S.S.E. at 15° and containing the following fauna :—

Posidoniella lævis (Brown), or young form of *Posidonomya Becheri*, Bronn.
Posidonomya Becheri, Bronn. (Abundant.)
Pterinopecten papyraceus (Sow.).
Glyphioceras. (Large reticulate form.)
? *Prolecanites compressus*.

The section at Teilia (lat. 53° 19′ 15″ N., long. 3° 22′ 55″ W.) has been frequently described, and the plants collected there form the subject of a paper by Mr. R. Kidston,[1] F.R.S., who in it says (p. 427) : "Little or no assistance is given in deciding this point [i.e. the horizon] by the molluscan remains, as some of them extend from the base to the top of the Carboniferous formation." The following list of the fauna collected at this locality enables the correlation of this horizon to be made with certainty and exactness, not only with those sections above described, but with others in widely separated areas :—

[1] Trans. Roy. Soc. Edinburgh, vol. xxxv (1888), pp. 419–428.

Posidoniella lævis (Brown).
Posidonomya Becheri (Bronn). (Common.)
Pterinopecten cf. *carbonarius*, Hind.
Rhynchonella sp.
Glyphioceras reticulatum (Phill.).
Orthoceras sp.
Spirorbis sp.
Ostracods.
Fish-remains.

Mr. Kidston's paper may be referred to for an account of the plants from this locality: it is interesting to note, however, that this flora occurs in the Pendleside Series of Poolvash, Isle of Man, Pendle Hill, and North Staffordshire, associated as at Teilia with a typical Pendleside fauna.

We are indebted to Mr. T. W. D. Gregory for the following analyses of samples of this limestone which were collected from the quarries at Teilia and near Prestatyn:—

	Teilia.	Near Prestatyn
Moisture	0·104 ...	0·53
Analysis of Dried Sample.		
Carbon dioxide (CO_2)	38·68 ...	26·76
Ferric oxide (Fe_2O_3)	0·73 ...	0·71
Aluminium oxide (Al_2O_3)	1·27 ...	0·69
Calcium oxide (CaO)	43·60 ...	32·57
Magnesium oxide (MgO)	0·61 ...	0·51
Soluble silica (SiO_2)	0·11 ...	0·32
Phosphorus pentoxide (P_2O_5) ...	trace ...	—
*Insoluble residue	14·91 ...	38·31
**Analysis of insoluble residue.*		
Organic matter + combined water ...	2·92 ...	0·95
Silica (SiO_2)	10·26 ...	34·55
Aluminium oxide (Al_2O_3)	1·70 ...	2·48
Ferric oxide (Fe_2O_3)	trace ...	trace

Some strata, possibly a little higher in the series, were examined in a quarry on the high side of the road leading from Holyweli to Brynford (lat. 53° 16′ 10″ N., long. 3° 13′ 10″ W.). We found similarly thin-bedded black limestones overlying finely laminated black shales, and all dipping off the flanks of the mass of Carboniferous Limestone of Halkyn Mountain. In the black limestones we found—

Posidonomya Becheri, Bronn. (Rather rare.)
Plant-remains. (Indeterminate, but not rare.)

In stratigraphical sequence the next horizon is exposed near the entrance to Nant-figillt at Hendre, where a brickworks is established for the manufacture of bricks, etc., from the soft laminated black shales which are quarried there (lat. 53° 12′ N., long. 3° 11′ 10″ W.). Near the floor of the quarry is a band of thin black limestone which is very fossiliferous, and has yielded the following:—

Lingula mytiloides, Sow. (In adjacent shales also.)
Posidoniella lævis (Brown).
P. minor (Brown).
Pterinopecten papyraceus (Sow.). (In shales also.)
Dimorphoceras Gilbertsoni (Phill.).
Glyphioceras cf. *Phillipsi*, Foord & Crick.
G. reticulatum (Phill.).

Higher again in the series a section consisting of laminated dark shales is seen on the eastern side of the Baggilt Old Road, near the bottom of the valley about $\frac{3}{8}$ mile from Holywell (lat. 53° 16′ 12″ N., long. 3° 12′ 35″ W.). The following fauna was collected:—

Posidoniella lævis (Brown). (Very abundant.)
Pterinopecten carbonarius, Hind.
P. papyraceus (Sow.).

Near the summit of the sharp rise from the bottom of the valley, 200 yards further on the same road from Holywell, there is an exposure of soft black shales, which are rather barren of fossil remains.

The cutting on the north side of the Glyn Abbot Road (lat. 53° 16′ 22″ N., long. 3° 12′ 20″ W.) presents a fairly thick series of soft, pyritous, black shales, which are the highest beds of the Pendleside Series examined *in situ* by us in this district. A few feet above the level of the road is a band of black limestone about 3 inches thick, which in one layer is crowded with a peculiar *Productus*, which is also found about this horizon at Congleton Edge, Cheshire, and according to Dr. A. Vaughan occurs in stage ϵ of the Bristol area. Concerning *Productus* ϵ, Dr. Vaughan reports that it shows effects of convergence with *Productus* aff. *Cora* and *P.* aff. *hemisphericus* and homœomorphy with *P. semireticulatus*. It is a very complex type, and is identical with the most abundant form which is found in the Upper *Dibunophyllum* zone and stage e near Wick, East Bristol area. In the above section the shales overlying the thin limestone yielded—

Lingula mytiloides, Sow.
Leiopteria longirostris, Hind.
Posidoniella lævis (Brown). (Very common.)
P. minor (Brown).
Pterinopecten carbonarius, Hind.
P. papyraceus (Sow.).
Actinopteria persulcata, M'Coy, sp.
Glyphioceras diadema, Berg.
G. Phillipsi, Crick.
Orthoceras Steinhaueri, Sow.
Reed-like plant-remains.

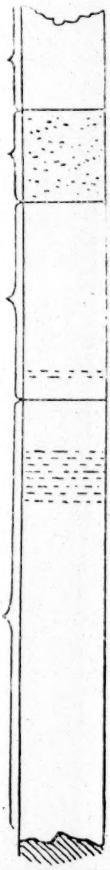
(*c*) *The Millstone Grit.*

This member of the Carboniferous system is represented in North Flint by the massive grit so extensively quarried in the neighbourhood of Gwespyr and Talacre, where its thickness is at least 300 feet; it is usually referred to as the Gwespyr Sandstone. There is a small exposure in the road leading from Kelston Farm to the bridge near the head of Talacre Dingle, whose stream, also, has cut through the same thick sandstone, where it forms steep bank-sides, and gives rise to the dantesque scenery for which the dingle is well known. At the top end of the smaller lake which the stream of the Dingle enters, there is a small exposure of 'crowstones.' At the village of Gwespyr the bedding-planes of the large blocks of grit obtained from the quarries are marked by abundant débris of leaves and stems of plants; *Stigmaria ficoides* (Sternb.) was collected from one of these layers.

Reference has been made (*ante*, p. 446) to the representative of the Gwespyr Sandstone near Berwig station, the most southerly point at which any representative of the Millstone Grit appears in force.

4. The actual Sequence as now established.

The chief result of our examination of this area of development of Carboniferous rocks is the discovery that the sequence is normal, in every respect, to that observed throughout the North Midlands. The structure of the country is fairly indicated by its topographical features, and the succession of the chief divisions of the Carboniferous system is not obscured or complicated by the various faults that traverse the district. Both the palæontological and lithological sequence agree most remarkably with that already established for the area of the southern portion of the Pennine Chain, as will be seen from the following diagram (Fig. 2) of the succession in North Wales :—



General Nomenclature.	Local Nomenclature.	Mining Classification.	Abundant and Characteristic Fossils, etc.
d. Coal-measures.	Coal-measures.	Coal-measures.	Coal-seams.
c. Millstone Grit.	Gwespyr Sandstone.		*Calamites*, *Stigmaria*, etc.
b. Pendleside Series.	Holywell Shales.	Watertight barrier.	*Posidoniella lævis* Fossiliferous bullions *Posidonomya Becheri* *P. membranacea*
	Teilia Beds, or Chert in places.		*Pterinopecten papyraceus.*
D_2	Cherts and Calcareous Grits in places.	Lead-measures.	*Productus longispinus.* *P. giganteus.*
	Aberdo Limestone.		*Lonsdaleia floriformis.* (*Cyathaxonia* beds.)
	Grey Limestone.		*Lithostrotion irregulare* *L. junceum* *L. Portlocki* *Spirifer triangularis.* (Abundant.) *S. trigonalis.* ,,
a. Carboniferous Limestone.	White Limestone.		*Amplexizaphrentis*
D_1			*Lithostrotion Martini.* *Productus Cora.* (Abundant.)
S_2	Brown Limestone.		*Chonetes papilionacea.* (Abundant.) *Cyathophyllum Murchisoni.*
Pre-Carboniferous.			*Seminula ficoides.* *Daviesiella Llangollensis.*

Note.—This diagram, Fig. 2, is not to scale.

The above general succession was made out from field-work and from analysis of the fossils collected during that work, but our conclusions received confirmation from an unexpected source which it is desirable to mention here. A few years ago a water-level was driven from Baggilt to the East Halkyn Mine, which passed through the whole series from the Coal-measures to the Carboniferous Limestone. We are much indebted to Mr. J. Powell Jones, of Holywell, for calling our attention to this, and for showing us the section of the tunnel. Mr. Jones also took the trouble of pointing out to us the débris from the excavation of the tunnel in the order in which it was drawn (so far as he could certify this), it having been tipped *seriatim* over a great area of ground. We saw several typical large Pendleside bullions, and from the shales we collected—

Posidoniella lævis (Brown).
Pterinopecten papyraceus (Sow.).
Goniatites.
Nautiloid form.
Acrolepis Hopkinsi (?).
Listracanthus sp.

We also observed a grit which Mr. Jones informed us was met with near the top of the cherts, and which was crowded with detached fish-remains (teeth, spines, etc.), representing undoubtedly the great bed at the top of the section at Gwernymynydd (p. 398). The full thickness of the Holywell shales was about 1,000 feet, as proved by this adit-level.

With respect to the correlation of the numerous exposures of Carboniferous Limestone there is more difficulty; we may, however, as a preliminary, make some observations on the range and distribution of the most important and most abundant fossils (chiefly Corals and Brachiopods) which occur throughout this district.

Seminula ficoides, Vaughan. This form characterises the lowest beds of the series, which may be seen at Llandulas and south of Dyserth. Its vertical range is rather limited, and for that reason it is of great value for stratigraphical purposes. At Llandulas and Minera it is associated with *Daviesiella Llangollensis* (Dav.), which also appears to have a limited range and yet possess a wide distribution. Both forms were very numerous; the latter occurs at Llandulas, Minera, and Eglwyseg ridge.

Cyathophyllum Murchisoni, E. & H. The range of this coral is very considerable, and its zone is mainly above that of *Seminula ficoides*, although they possibly overlap to a slight extent. In the lower portion of the zone, it is very abundant at Bwlch-y-gwynt, near Dyserth, near Llanferres, Llanarmon, Eglwyseg ridge, and near Sweeney Mountain, and at nearly all these localities it is associated with *Chonetes papilionacea*, Phill., which is also abundant. The highest beds in which it occurs are seen near Axton Mine, at Hendre, and at Treflach Wood Quarries, where it occurs near the base of *Productus giganteus* zone, and is associated with *Campophyllum Murchisoni*, E. & H.

Cyathophyllum cf. *regium*, Phill. This coral was found in beds just below the highest of the series at Hendre, Minera, Corwen, Eglwyseg ridge, and Treflach Wood Quarries, and was always associated with *Lithostrotion irregulare* (Phill.), *L. junceum* (Flem.),

L. Portlocki (Bronn), and frequently with *Lonsdaleia rugosa*, M'Coy, and *Phillipsastræa radiata*, E. & H. It differs somewhat from the typical *C. regium* from the Bristol area.

Dibunophyllum. Corals belonging to this genus are distributed through the whole series of the Carboniferous Limestone of North Wales, with the possible exception of the lowest of these or the *Seminula ficoides* zone.

Lithostrotion Martini, E. & H. This coral appears to characterise those limestones that occupy an intermediate position, and it has therefore a moderate range, extending from the base of *Cyathophyllum Murchisoni* zone, as seen at Bwlch-y-gwynt and near Llanferres, to beds 300 feet higher in the series at Pot Holes, in the White Limestone on Holywell Common above the Grange Quarry (see section, Fig. 1, p. 394), at Gwaenysgor, and in the White Limestone overlying the Brown Limestone of the Eglwyseg ridge.

Lithostrotion irregulare (Phill.), *L. Portlocki* (Bronn), *L. junceum* (Flem.). These species are found most abundantly in beds which form the uppermost 100 feet of the Carboniferous Limestone of this district, as exposed at Hendre, Gwernymynydd, Pot Holes, Minera, Ty-nant ravine, Corwen, and Treflach Wood Quarries; they are thus seen to be widely distributed.

Calophyllum θ, Campophyllum Murchisoni, Clisiophyllum Curkeenensis. These three corals are not very abundant, and have only been found in the upper beds of limestone occurring at Waenbrodlas, near Gwyndy, and at Treflach Wood Quarries.

Spirifer triangularis (Mart.), *S. trigonalis* (Mart.), d'Orb. These Brachiopods practically make up whole beds in quarries at Gwernymynydd and north of Gwyndy, at an estimated distance of 100 feet from the top of the limestone.

Productus longispinus, Sow. This is abundant in the uppermost beds only of the limestone, such as the Aberdo Limestone horizon, and it extends into the cherts at Gronant.

Amplexi-zaphrentis. This genus is fairly abundant in the upper portion of the limestone, and has a wide distribution.

Clisiophyllum aff. *Curkeenensis*, Vaughan, *Calophyllum θ*, Vaughan. These two species of Corals have only been found near the top of the limestone, and are more restricted than *Productus longispinus*, Sow.

Productus giganteus (Mart.). These large Brachiopods are very abundant in the top beds of the limestone; after a distance of 100 feet from the top they are of sparing occurrence, and are not met with in those beds where *P. Cora*, d'Orb., and *P. hemisphericus* are so abundant near the base of *Cyathophyllum Murchisoni* zone.

By analysis of the fossil lists, then, we are enabled to correlate, with varying degrees of precision, the different exposures of the Carboniferous Limestone in this part of North Wales. In ascending order, the localities affording sections in the same horizons may thus be summarised:—

1. The lowest limestones at Llandulas; Pentre-bach, near Dyserth; and Eglwyseg ridge, near Dibrun Uchaf. Characteristic fossils: *Seminula ficoides, Daviesiella Llangollensis.*

2. The beds east of Bwlch-y-gwynt, at the foot of the hill near Llanferres, and near Llanarmon. Characteristic fossils: *Cyathophyllum Murchisoni, Chonetes papilionacea, Productus Cora, P. hemisphericus.*

3. Intermediate strata, whose position relative to one another cannot as yet be definitely assigned, appear at the surface at Meliden, Gwaenysgor, Axton Mine, Garreg, and Cat Hole, east of the Loggerheads Inn. Characteristic fossils: *Productus Cora* (few), *P. hemisphericus* (common), *P. giganteus* (not rare). The quarry at Holywell Common, above the Grange Farm, is probably at the upper limit of this horizon (see Fig. 1, p. 394).

4. The next stage is exposed at Hendre, Gwernymynydd, north of Gwyndy, Pot Holes (the last-named quarry can be definitely correlated with the "No. 1 Encrinital Limestone" at Gwernymynydd; see p. 398), Minera, Ty-nant ravine, Corwen, and Treflach Wood

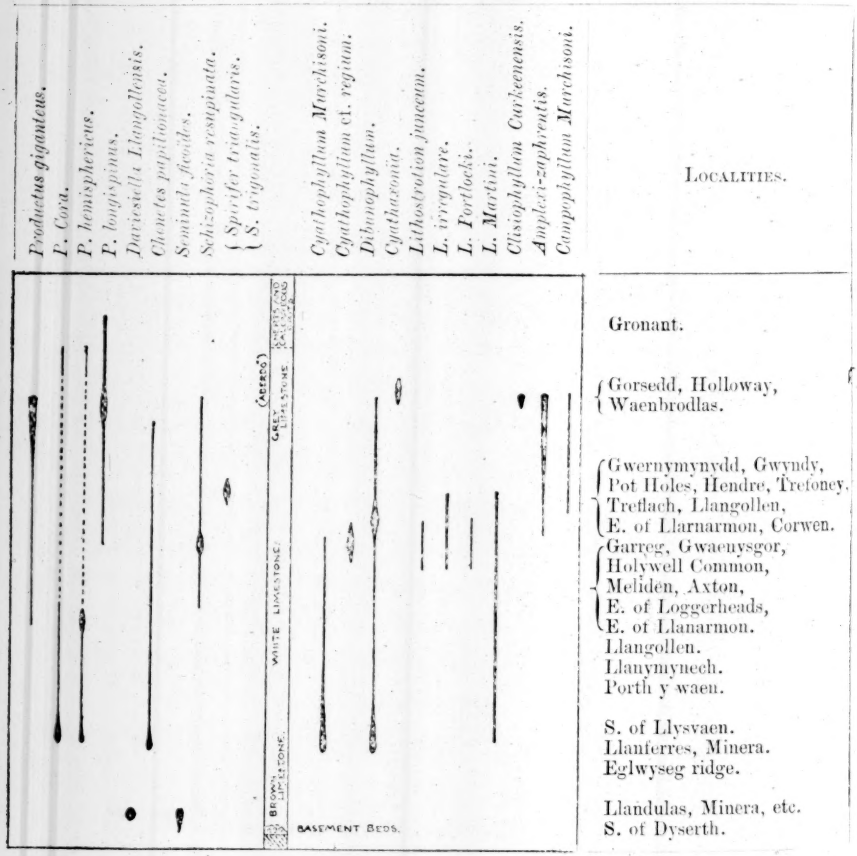


FIG. 3.—Diagram showing the stratigraphical distribution of the most important fossils.

Quarries. Characteristic fossils: *Amplexi-zaphrentis, Lithostrotion irregulare, L. junceum, L. Portlocki, Spirifer bisulcatus, S. triangularis, S. trigonalis.*

5. The uppermost beds, which in all probability were not deposited over the whole of this Carboniferous area (p. 394), are seen at Trelogan, Gorsedd, Holloway, Waenbrodlas, Eglwyseg ridge, and Treflach Wood Quarries. Characteristic fossils:—

Cyathaxonia Rushiana.
Clisiophyllum Curkeenensis.
Callophyllum sp.
Campophyllum Murchisoni.
Lonsdaleia floriformis.
Productus giganteus.
P. longispinus.

6. The very highest member of the Carboniferous Limestone Series are the cherty beds and their equivalent calcareous grits or Cefn-y-Fedw Sandstone, as exposed near Pentre Halkyn, Holloway, Gronant, Gorsedd, Trelogan, Prestatyn, and Graianryd. The grits are characterised by the presence of abundant fish-remains in a more or less fragmentary state.

(*To be concluded in our next number.*)

IV.—The Somabula Diamond Field of Rhodesia.

By F. P. Mennell, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

THE last few years have inaugurated a new era in the history of the South African diamond deposits, inasmuch as rich bodies of diamantiferous ground have been located at great distances from localities which have previously been worked successfully. The group of which the Premier Mine is the best known member is the most striking example of this extension of area, but the centre of gravity of the diamond-mining industry seems to be gradually shifting northward, and the opening up of the interesting deposit of the Somabula Forest, so far north of any other known occurrence, foreshadows the development of an important branch of the industry in the Cinderella of the South African provinces, as Rhodesia has been not inaptly termed.

No detailed or authentic description of the Somabula field has so far appeared. The writer briefly referred to the occurrence of a remarkable gravelly deposit west of Gwelo in his "Geology of Southern Rhodesia," and ascribed its formation to the Tertiary period, a course which appears fully justified by more recent and detailed investigation. He had already seen diamonds and other gems from the locality, but had not been made aware of their source. Last year he made an examination of the ground on behalf of the South African Options Syndicate, who hold a large area on the field and who have just erected plant for producing diamonds on a large scale. The reports of their preliminary operations will have shown that a rich deposit of good quality stones has been opened up. A large quantity were disposed of at a price which works out at £3 17*s.* per carat, and a smaller parcel sold more recently fetched £6 per carat. The following notes, for permission to publish which I am indebted to the Syndicate, are intended to

afford some idea of the geological and mineralogical features of the field, of which I hope to give a much more detailed account at an early date.

The diamond area may be described as a tongue of the Somabula Forest stretching along the central plateau of Rhodesia from the Uvungu River for about seven miles in the direction of Gwelo. The beds of which it consists are undoubtedly younger than the Forest Sandstones, as shown by their numerous pebbles of agates derived from the lavas interbedded with those rocks, but they are probably very different in age, and may perhaps be regarded as the uppermost portion of the Forest Sandstone series. They directly overlie the granite of the watershed, on to the apex of which they extend, but further down the Uvungu River the ordinary Forest Sandstones are met with. The general sequence appears to be—

Somabula Beds.	5.	Surface rainwash, etc., chiefly redistributed gravel and sand (often absent)	say 10 feet
	4.	Red and white sands	say 40 feet
	3.	Gravel, with partings of clay, etc.	say 40 feet
	2.	White micaceous sand ... ... resting unconformably upon	30 feet
	1.	Granite.	

The top of the upper sandy beds is not seen, but the thickness given is probably well within the mark. The levels of the granite bed-rock also vary considerably, and the beds themselves tend to assume a lenticular shape, so that it is impossible to give more than a rough idea of their proportionate development.

The upper sands, which have been entirely removed by denudation from some of the ridges and from all the lower ground, are sometimes clayey and stained red by iron oxides and sometimes fine and white. In a shaft at one spot on the slope of a ridge, an actual thickness of 16 feet was passed through before reaching the underlying gravel. It may be stated, however, that so heavy an overburden is met with on few parts of the diamantiferous area.

The gravel itself is composed of beautifully rounded pebbles in a matrix of sandy clay, sometimes ferruginous. There are some concretionary masses of iron-cemented sandstone, and the gravel is converted in places into a hard conglomerate by infiltrated iron oxides, or more rarely by silica. The pebbles are mostly of quartz, frequently rock crystal, but they also include jaspery banded ironstone, chert, agate, hard sandstone or quartzite, and occasional large and small pieces of silicified wood, as well as fragments of granite and chloritic schist. Large boulders are comparatively rare. The silicified wood, though distributed about in all sorts of positions, may possibly have been *in sitû*; the granite and schist last mentioned are the only other constituents of the deposit that are not well rounded. The presence of the agate, as already mentioned, shows the deposit to be newer than the lavas of the Forest Sandstone series. In one shaft 25 feet of gravel had been passed through at the time of my visit without any indications of approaching the base, and more recent work has shown that my estimate of 40 feet is probably a moderate one for the maximum thickness.

The lower sandy beds have obviously derived most of their materials from the underlying granite. They are micaceous throughout, the upper and lower parts south of the railway being clayey with a bed of clean sand in between. The base shows fragments of decomposed granite, and it is difficult to fix the point where the bed-rock really begins.

It is clear that in these sands and gravels we are not dealing with the insignificant accumulations of the present-day river system. This is no less evident from the character and distribution of the deposits than from their position on the crest of what is now the main watershed of the country. Their extent is quite in keeping with a lacustrine origin; on the other hand, they correspond closely with the alluvial deposits of rivers which have eroded their valleys practically to the lowest possible level, and have for long been chiefly occupied in widening them and spreading the materials furnished by the process evenly over their flood plains. The Somabula beds may therefore be set down provisionally as due to the action of an important Tertiary river or river system, probably a feeder of the great lake which must once have filled the adjacent portion of the Zambesi basin, and draining an area chiefly occupied by granite and the Archæan banded ironstone.

The gravels of the Somabula are interesting from their unique lithological character as far as Rhodesia is concerned, but their chief interest naturally arises from their being the source of various gem stones, particularly the diamond. The diamonds themselves are peculiar as almost invariably of a green shade in the rough; this is, however, entirely lost in cutting. They occur in very good crystals, principally octahedra, spinel twins of two octahedra, twinned tetrahedra, twinned hexatetrahedra, dodecahedra, etc. Etched triangles are characteristic of the tetrahedral faces. Worn stones are almost entirely absent. The mineralogical associates of the precious stones are not precisely similar to those of the Kimberley diggings or of the more recent Transvaal discoveries, but they nevertheless present a general resemblance to those of the localities named. Garnets are often common, but are not of the blood-red Kimberley variety. Ilmenite too is uncommon. Both magnetite and hæmatite, of which grains are numerous, are evidently derived from the banded ironstone, while the source of the zircon and of the mica (muscovite) is equally clearly the granite; these minerals have no necessary connection with the original matrix of the diamond. This too is probably the case with the beryls which also occur. The typical minerals of the deposits are (besides the diamond) enstatite, chrysoberyl, kyanite, and sapphire. Enstatite is the commonest of the minerals popularly grouped together under the name of olivine at Kimberley, but is here a remarkably hard brownish variety. It is an abundant constituent of the sorted material from the puddling machines. Some of the grains are fairly clear, and might almost be taken for garnets on account of their red-brown colour. Chrysoberyl is quite abundant for so rare a stone. The prevailing variety is yellow, but the opalescent

(precious) 'catseye' and the form known as 'alexandrite,' which is green by day- and red by candle-light, also occur. This mineral would seem to be usually a product of contact-metamorphism; at the same time, although it is not strictly analogous in a chemical sense, its similarity of composition and isomorphism with olivine are to be noted. As a gem the ordinary variety is actually called 'chrysolite,' one of the names properly applied to olivine. Kyanite and sapphire are unequivocal contact minerals, so are rutile and tourmaline, whose occurrence may also be noted. The presence of the first-named is interesting owing to its softness, which makes its survival rather remarkable. Of the sapphires both the blue and colourless varieties occur, while true rubies and Oriental amethysts are also found, though they are distinctly rare even for such scarce stones. Another stone whose occurrence may be noted is the so-called 'Somabula blue.' This is harder and heavier than common beryl, and is possibly a variety of topaz; when cut it is one of the most beautiful gems imaginable.

With regard to the origin of the gems, the mere richness of the deposit is sufficient to indicate a near source for the diamond, although many of the constituents of the gravel itself have obviously travelled far. Despite theories to the contrary, it seems certain from the evidence obtained in New South Wales as well as in this country that what is commonly called 'blue ground' is in all cases the original source of the diamond, and the great abundance of enstatite, as well as the presence of garnets, points to the same origin in the case of the Somabula field. I am aware that Professor Gregory after a hurried inspection of the ground has pronounced the opinion that the diamond comes from pegmatite veins, but such an idea is so completely at variance with the local conditions and with all that we know of diamond occurrences that it scarcely merits discussion. I have little doubt that it will not be long before the pipe which produced the diamonds is discovered, and that it will present, apart from slight local peculiarities, all the usual features of the South African mines already known.

V.—A Key to the Published Figures of the Cretaceous Forms of the Polyzoan genus *Entalophora*.

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

In view of the vigour with which the investigation of the English Chalk is at present being carried out by amateurs, resulting in the accumulation of large numbers of fossil specimens which give rise to difficulties of nomenclature, the publication of a key to aid collectors in determining the specific position of members of one of the largest Cretaceous genera of the phylum Polyzoa does not seem inappropriate.

The most inclusive work on Cretaceous Polyzoa is the British Museum Catalogue. While this gives descriptions of such species as the British Museum possesses, with figures of many, and references to all the literature on the group, it does not present any

tabular arrangement of forms nor easy means whereby the different species of a genus may be compared for identification by a collector.

Fourteen species of *Entalophora* are described in the Catalogue as being represented in the Museum collection, and references with a few words of description are given of thirty-three more described forms. Without access to the works mentioned the task of identification becomes impossible, and the collector can hardly be blamed if he leaves alone the Cretaceous forms of *Entalophora*.

It is hoped that, prefaced with a few explanatory remarks, the key here given will be found intelligible.

First, all references and descriptions without figures have been ignored, because in the case of such small differences of detail as occur between the 'species' in this genus, descriptions unaccompanied by figures are useless unless (and in no case is this so) they are such as to compare with the whole series of described forms.

Next, the question of synonymy has been left alone. All the figures which can be referred to this genus are mentioned, and references given as in the British Museum Catalogue. In many cases several figures fall under one heading; and it will be generally found that they are grouped as one species in the British Museum Catalogue. But by no means does it follow that the converse is true; for forms widely separated on the table may be different topomorphs[1] of one species. This only demonstrates the artificiality of the grouping in the key. For this artificiality no apology is tendered; for the 'genus' itself is probably as artificial as other Polyzoan genera; and the key is only meant to help the identification of figured forms, and not to show genetic relationships. It is to be hoped that further investigation of forms, especially with regard to the horizons at which they occur, will throw light on these. Meanwhile the accurate recognition of described forms is the first step towards their further elucidation.

The terms used in the key are for the most part self-explanatory. The size and arrangement of the apertures are the characters chiefly used. The distances between the apertures are described in terms of the diameter of the aperture—the vertical distance being that in a proximal-distal direction—along the branch, and the transverse distance at right angles to this.

The term *emergent* is used of zoœcia whose upper surface is arched well above the general level of the zoarium, which therefore has a surface with a crenulate outline. On the other hand a zoarium is composed of *immersed* zoœcia whose surface is flat, though the outlines of the zoœcia may be apparent thereon. The terms are comparative, that is, degrees of emergence and immersion are exhibited.

The measurements and statements in the table are approximate, for allowance has to be made for some zoœcial variation within even small pieces of a zoarium.

[1] A topomorph is a term, applicable to Polyzoa and colonial Madreporaria, denoting an individual or group of individuals differing in form from those surrounding it. See Geol. Mag., 1906, pp. 66–68.

A. *Branches cylindrical.*

I. Apertures distant (i.e. vertical distance between the apertures more than about four times the diameter of the aperture).

a. Apertures very distant and zoaria thin.

α. Apertures two or three in the breadth of a branch.

1. Zoœcia immersed.

a. Zoarium smooth.

α. Zoarium exceedingly thin and delicate 1

β. Zoarium not so thin and delicate 2

b. Zoarium with transverse striæ.

α. Transverse striæ faint and close 3

β. Transverse striæ coarser and farther apart 4

c. Zoarium with outlines of zoœcia marked, though the zoœcia are not emergent.

α. Apertures arranged in pairs 5

β. Apertures irregularly arranged.

1. Apertures very distant (6–8 diameters), zoœcia strictly cylindrical.

a. Apertures 1–2 in the breadth of a branch.

α. Zoarium exceedingly thin and delicate 6

β. Zoarium not so thin nor delicate 7

b. Apertures 2–4 in breadth of a branch 8

2. Apertures not so distant (4–6 diameters), zoœcia fusiform ... 9

2. Zoœcia emergent.

a. Zoœcia only somewhat emergent 10

b. Zoœcia very emergent 11

β. Apertures four to six in the breadth of a branch.

1. Apertures arranged in twos and threes (zoœcia are shorter than in *geminata* and zoœcial boundaries less marked) 12

2. Apertures irregularly arranged.

a. Zoœcia very emergent 13

b. Zoœcia somewhat emergent, zoœcial boundaries very clearly marked 14

c. Zoœcia immersed, though zoœcial boundaries are shown 15

b. Apertures comparatively close, and zoaria stout compared with diameter of apertures. Peristomes very high.

α. Apertures of smaller diameter (·04–·06 mm.) 16

β. Apertures of larger diameter (·08–·12 mm.) 17

II. Apertures close (i.e. vertical distance between the apertures less than about four times the diameter of the aperture).

a. Apertures two or three in the diameter of a branch.

α. Zoœcia emergent 18

β. Zoœcia immersed 19

b. Apertures four to eight or more in the diameter of a branch.

α. Zoœcia emergent.

1. Apertures in whorls 20

2. Apertures in spirals.

a. Zoœcia cylindrical 21

b. Zoœcia fusiform 22

β. Zoœcia immersed.

1. Apertures comparatively distant (2–4 diameters apart).

a. Apertures regularly arranged in whorls 23

b. Apertures regularly arranged in spirals.

α. Apertures about four or five in the breadth of a branch ... 24

β. Apertures about eight in the breadth of a branch.

1. A transverse ridge across each zoarium just beneath the aperture 25

2. No transverse ridges across the zoœcia 26

c. Apertures irregularly arranged 27

2. Apertures close (1–2 diameters apart vertically).

a. Diameter of apertures ·35 to ·4 mm.

α. Branches short and stumpy 28

β. Branches normal though stout 29

b. Diameter of apertures ·1 to ·2 mm.
a. Transverse distance between apertures about the diameter of one aperture 30
β. Transverse distance between apertures ½ to ¾ diameters of aperture 31
c. Diameter of aperture ·04 to ·1 mm.
a. Peristomes moderately high 32
β. Peristomes very high 33
III. Apertures close, but bare patches on the zoarium 34

B. *Branches compressed.*
I. Apertures transversely elongate 35
II. Apertures circular.
a. Zoœcia emergent.
1. Apertures very distant (four to six diameters apart vertically)... ... 40
2. Apertures distant (three to four diameters apart vertically) 36
3. Apertures close (two and a half diameters apart vertically) 37
b. Zoœcia immersed.
1. Zoarium transversely striate 38
2. Zoarium smooth.
a. Vertical distance between apertures 3 to 6 times their diameter.
a. Boundaries of zoœcia not apparent... 39
b. Boundaries of zoœcia clearly marked 40
β. Vertical distance between apertures 1 to 3 times their diameter.
a. Lateral distance between apertures 2 to 3 times their diameter ... 41
b. Lateral distance between apertures ½ to 1½ times their diameter.
1. Lateral distance ½ a diameter. Diameter of aperture about ·3 mm. 42
2. Lateral distance 1–1½ diameters. ? Diameter of aperture about ·1 mm. 43

C. *Branches triangular in cross-section* 44

D. *Zoarium cylindrical with a cup-shaped top* 45

E. *Zoarium clavate.*
I. Apertures close (vertical distance between the apertures about 3 diameters of an aperture and lateral distance about 1½). Apertures tending to an arrangement in whorls 23
II. Apertures distant (vertical distance between the apertures 3–5 diameters of an aperture). Apertures irregularly arranged.
a. Zoœcia thoroughly emergent 46
b. Zoœcia somewhat emergent... 47
c. Zoœcia immersed 48

1. *Entalophora Pergensi*, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., vol. i, pl. x, figs. 5, 7 ... ... *E. Pergensi.*
2. *Pustulipora virgula*, von Hagenow, 1851: Bry. Maastr. kr., pl. i, fig. 3 ... ... *E. virgula.*
Entalophora virgula, var. *alternata*, Gregory: loc. cit., pl. x, fig. 3. ,,
E. virgula, var. *subgracilis*, Gregory: loc. cit., pl. x, fig. 4. ,,
E. virgula, var. *varipora*, Gregory: loc. cit., pl. xi, fig. 2. ,,
? *E. virgula*, Gregory: loc. cit., pl. xi, fig. 16. ,,
Pustulipora rustica, von Hagenow, 1851: loc. cit., pl. i, fig. 5. ,,
P. nana, von Hagenow, 1851: loc. cit., pl. i, fig. 4. ,,
Entalophora varipora, Beissel, 1865, Bry. Aach. kr.: Nat. Verh. holl. Maatsch. Wet., ser. II, vol. xxii, pl. x, fig. 123. ,,
E. iconensis, d'Orbigny, 1851: Bry. Crét., pl. 616, figs. 12–14. ,,
E. subgracilis, d'Orbigny, 1851: loc. cit., pl. 621, figs. 4–6. ,,
E. alternata, d'Orbigny, 1851: loc. cit., pl. 621, fig. 7. ,,
? *E. santonensis*, d'Orbigny, 1851: loc. cit., pl. 623, figs. 15–17. ,,
? *E. variegata*, d'Orbigny, 1851: loc. cit., pl. 622, figs. 18–21. ,,

3. *Entalophora proboscidea*, Pocta, 1892, Mech. Koryc. Hory.: Ceska Ak. Fr. Jos. Pratze, sect. ii, pl. ii, figs. 23, 24 ... ... *E. virgula.*
E. virgula, var. *raripora*, Gregory, 1899: loc. cit., pl. x, fig. 1. ,,
E. virgula, Gregory, 1899: loc. cit., pl. x, fig. 2; pl. xi, fig. 18. ,,
4. *E. raripora*, d'Orbigny, 1851: loc. cit., pl. 621, figs. 1–3. ,,
E. raripora, Novak, 1877, Bry. böhm. kr.: Denk. Ak. Wiss. Wien., vol. xxxiii, pl. x, figs. 1, 2. ,,
5. *Pustulipora geminata*, von Hagenow, 1851: loc. cit., pl. i, fig. 11. *E. geminata.*
Entalophora geminata, Gregory, 1899: pl. x, fig. 8. ,,
6. *E. Pergensi*, Gregory, 1899: pl. x, fig. 6 ... ... *E. Pergensi.*
7. *E. raripora*, Beissel, 1865: loc. cit., pl. x, fig. 120 ... ... *E. virgula.*
8. *E. raripora*, Novak, 1877: loc. cit., pl. viii, figs. 1–5. ,,
E. echinata, Gregory, 1899: pl. xi, fig. 17 ... ... *E. echinata.*
9. *E. vassiacensis*, d'Orbigny, 1853: loc. cit., pl. 753, figs. 13–15. *E. vassiacensis.*
10. *E. raripora*, Frie, 1883, Iserch: Arch. naturw. Landesf. Böhm, vol. v, No. 2, p. 125, fig. 107 ... ... *E. virgula.*
11. *E. virgula*, von Reuss, 1872, Bry. unt. Quad.: Palæontogr., vol. xx, pt. 1, pl. xxix, figs. 1, 2. ,,
E. raripora, Vine, 1885, Notes Cambr. Gr.: Proc. Yorks. Geol. Soc., new ser., vol. ix, pl. i, figs. 1, 2. ,,
E. proboscidea, Pergens, 1892, Nouv. Cycl. Crét.: Bull. Soc. Belge Géol., vol. iv (1890), Mém., pl. xi, fig. 6. ,,
E. carantina, d'Orbigny, 1853: loc. cit., pl. 753, figs. 16–18 ... *E. geminata.*
12. *E. conjugata*, von Reuss, 1872–3: loc. cit., pl. xxix, fig. 8 ... *E. conjugata.*
13. *E. fecunda*, Pocta, 1892: loc. cit., pl. ii, figs. 17, 18; pl. iii, figs. 14, 15 ... ... *E. fecunda.*
Pustulipora tubulosa, von Hagenow, 1851: loc. cit., pl. i, fig. 2. *E. tubulosa.*
14. *Entalophora fecunda*, Novak, 1877: loc. cit., pl. vi, figs. 22–27 ... *E. fecunda.*
E. echinata, Gregory, 1899: loc. cit., pl. x, fig. 13 ... ... *E. echinata.*
15. *E. soror*, Pocta, 1892: loc. cit., pl. iii, figs. 9–13 ... ... *E. soror.*
16. *E. horrida*, d'Orbigny, 1851: loc. cit., pl. 621, figs. 13–15 ... *E. horrida.*
E. horrida, Gregory, 1899: loc. cit., pl. x, fig. 9. ,,
17. *Pustulopora echinata*, Roemer, 1840: Verst. nordd. kr., pl. v, fig. 23. *E. echinata.*
P. echinata, von Reuss, 1846: Verst. böhm. kr., pl. xiv, fig. 4. ,,
Entalophora echinata, d'Orbigny, 1851: loc. cit., pl. 622, figs. 15–17. ,,
E. gracilis, d'Orbigny, 1851: loc. cit., pl. 617, figs. 1–4. ,,
E. tennis, d'Orbigny, 1851: loc. cit., pl. 619, figs. 10–12 (peristomes worn). ,,
E. linearis, d'Orbigny, 1851: loc. cit., pl. 622, figs. 5–7. ,,
? *E. pulchella*, von Reuss, 1872–3, Bry. unt. Quad.: Palæontogr., vol. xx, pt. 1, pl. xxix, fig. 3. ,,
E. echinata, Gregory, 1899: loc. cit., pl. x, figs. 10–12; pl. xi, fig. 1. ,,
? *Entalophora* sp., Gregory, 1899: loc. cit., pl. xi, fig. 3 ... ... *E.* sp.
18. *E. Conradi*, Gabb & Horn, 1862, Mon. Poly. N. Amer.: Journ. Acad. Sci. Nat. Phil., ser. II, vol. v, pl. xxi, fig. 59... ... *E. Conradi.*
19. *Vincularia cretacea*, d'Orbigny, 1851: loc. cit., pl. 600, figs. 17–19. *E. cretacea.*
? *Entalophora filiformis*, d'Orbigny, 1851: loc. cit., pl. 622, figs. 1–4. *E. echinata.*
? *E. cretacea*, Gregory, 1899: loc. cit., pl. xi, fig. 12 ... ... *E. cretacea.*
? *E. madreporacea*, var. *inconstans*, Gregory, 1899: loc. cit., pl. xi, fig. 13 ... ... *E. madreporacea.*
20. *Laterotubigera varapensis*, de Loriol, 1863: Invert. Néoc. Int. Salève, pl. xvi, fig. 1 ... ... *E. varapensis.*
21. *Entalophora sarthacensis*, d'Orbigny, 1851: loc. cit., pl. 619, figs. 6–9 ... ... *E. vendinnensis.*
Pustulopora echinata, Michelin, 1845: Icon. Zooph., pl. liii, fig. 5 ... ... ,,
22. *Entalophora neocomiensis*, de Loriol & Gillièron, 1869: Ung. Land. Mém. Soc. Helvét. Sci. Nat., vol. xxiii, pl. ii, fig. 19. *E. neocomiensis* (1).
23. *E. heros*, Pocta, 1892: loc. cit., pl. ii, figs. 25–30... ... ... *E. heros.*

24. *Ceriopora madreporacea*, Goldfuss, 1827: Petref. Germ., pl. x, figs. 12*a. b* ... ...*E. madreporacea.*
Pustulopora madreporacea, Bronn, 1838: Leth. Geog., 2nd ed., pl. xxix, fig. 6. ,,
P. madreporacea, von Reuss, 1846: Verst. böhm. kr., pl. xiv, fig. 5. ,,
Ceriopora madreporacea, von Hagenow, 1846: in Geinitz, Grund. Verst., pl. xxiii*b*, fig. 14. ,,
Pustulopora (*madreporacea*, de Blainville, 1834: Man. Act., *Pustulipora*) pl. lxx, fig. 5. ,,
Pustulipora madreporacea, von Hagenow, 1851: Bry. Maastr. kr., pl. i, fig. 8. ,,
Entalophora madreporacea, d'Orbigny, 1861: Bry. Crét., pl. 623, figs. 1–3. ,,
E. madreporacea, var. *inconstans*, Gregory, 1899: loc. cit., pl. x, fig. 14. ,,
E. madreporacea, var. *Benedeni*, Gregory, 1899: loc. cit., pl. x, fig. 15. ,,
E. subregularis, d'Orbigny, 1851: loc. cit., pl. 621, figs. 16–18. ,,
Pustulipora Benedeni, von Hagenow, 1851: Bry. Maastr. kr., pl. i, fig. 6. ,,
? *Eschara Ehrenbergi*, von Hagenow, 1840, Mon. Rüg., pt. ii: N. Jahrb., 1840, pl. ix, fig. 2. ,,
Entalophora inconstans, d'Orbigny, 1853: loc. cit., pl. 754, figs. 15–17. ,,
E. kolinensis, Novak, 1877: loc. cit., pl. vii, figs. 11–13. ,,
25. *E. rugosa*, d'Orbigny, 1853: loc. cit., pl. 754, figs. 18–20 ... *E. rugosa.*
26. *E. pustulosa*, d'Orbigny, 1853: loc. cit., pl. 755, figs. 1–3 ... *E. symmetrica.*
27. *E. neocomiensis*, d'Orbigny, 1851: loc. cit., pl. 616, figs. 15–18 ... ... *E. neocomiensis* (1).
28. *E. brevissima*, d'Orbigny, 1851: loc. cit., pl. 625, figs. 5–10 ... *E. brevissima*
29. *E. salevensis*, de Loriol, 1863: Invert. Int. Salève, pt. ii, pl. xvi, figs. 4*a–d*. De Loriol & Gillièron, 1869: loc. cit., pl. ii, fig. 20. *E. salevensis.*
30. *E. symmetrica*, d'Orbigny, 1853: loc. cit., pl. 755, figs. 4–6. *E. symmetrica.*
31. *E. ramosissima*, d'Orbigny, 1851: loc. cit., pl. 618, figs. 1–5. *E. ramosissima.*
32. *E. vendinnensis*, d'Orbigny, 1851: loc. cit., pl. 617, figs. 15–17. Von Reuss, 1872–3, Bry. Unt. Quad.: Palæontogr., vol. xx, pt. 1, pl. xxix, figs. 4–5 ... ... *E. vendinnensis.*
33. *E. horrida*, d'Orbigny: see No. 16.
34. *E. Gamblei*, Gregory, 1899: loc. cit., p. 248, figs. 26, 27. ... *E. Gamblei.*
35. *Bidiastopora regularis*, d'Orbigny, 1853: loc. cit., pl. 756, figs. 4–6 ... ... *E. regularis.*
36. *B. elegans*, d'Orbigny, 1851: loc. cit., pl. 627, figs. 5–8 ... *E. elegans.*
Entalophora compressa, d'Orbigny, 1851: loc. cit., pl. 619, figs. 1–5. *E. compressa.*
Bidiastopora gracilis, d'Orbigny, 1853: loc. cit., pl. 755, figs. 10–12. ,,
B. Mariæ, d'Orbigny, 1853: loc. cit., pl. 755, figs. 13–15. ,,
37. *B. crassa*, d'Orbigny, 1851: loc. cit., pl. 627, figs. 13–16 ... *E. crassa.*
38. *B. rustica*, d'Orbigny, 1851: loc. cit., pl. 628, figs. 1–4 ... ... *E. virgula.*
39. *B. cultrata*, d'Orbigny, 1851: loc. cit., pl. 627, figs. 9–12 ... *E. cultrata.*
40. *B. inornata*, d'Orbigny, 1853: loc. cit., pl. 755, figs. 7–9 ... *E. inornata.*
41. *B. neocomiensis*, d'Orbigny, 1853: loc. cit., pl. 784, figs. 9–11 ... ... *E. neocomiensis* (2).
42. *Entalophora gigantopora*, Vine, 1885: loc. cit., pl. i, fig. 3. Gregory, 1899: loc. cit., pl. xi, fig. 4 ... ... *E. gigantopora.*
43. *Bidiastopora subacuta*, Peron, 1888, Craie S.E. Bassin, Anglo-Par.: Bull. Soc. Sci. nat. Yonne, vol. xli, pl. iii, figs. 27–29. *E. subacuta.*
44. *B. triangularis*, d'Orbigny, 1853: loc. cit., pl. 755, figs. 16–18. *E. triangularis.*
45. *Entalophora anomalissima*, Novak, 1877: loc. cit., pl. vii, figs. 14–16. Počta, 1892: loc. cit., pl. ii, figs. 19–22. *E. anomalissima.*
46. *E. elavata*, d'Orbigny, 1851: loc. cit., pl. 621, figs. 8–12 ... *E. echinata.*
47. *E. juvenis*, Počta, 1892: loc. cit., pl. iv, figs. 19, 20 ... ... *E. juvenis.*
48. *Clavisparsa turbinata*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. i, fig. 7 ... ... *E. turbinata.*

NOTICES OF MEMOIRS, ETC.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, YORK, 1906. — ABSTRACTS OF PAPERS READ BEFORE SECTION C (GEOLOGY).

I.—THE GLACIAL DEPOSITS OF THE EAST OF ENGLAND. By F. W. HARMER, F.G.S.

THE eastern part of Norfolk forms a low-lying area which, could the glacial beds be removed, would seldom rise above the 100 foot contour. This region, therefore, with the Fenland, was the first part of East Anglia to be overrun by the North Sea ice. None of the resulting moraine (similar, for example, to the Contorted Drift of Cromer) is now found in the Fenland, as it has been destroyed by the subsequent advance of the inland ice-stream to which the Chalky Boulder-clay was due; its former presence is evidenced by the occasional occurrence there of igneous erratics like those found on the Norfolk coast.

At this period, moreover, the North Sea ice must also have advanced over Holderness and the East Lincolnshire plain. A portion of the glacial deposits of those regions may therefore be of equivalent age to the Contorted Drift of Cromer. As, however, the movement of the Scandinavian glacier from north to south must have been gradual, the Contorted Drift may be somewhat newer than the earliest of the glacial beds of North Britain.

Before the deposition of the Chalky Boulder-clay in East Anglia, the North Sea ice had withdrawn from a great part of that region, and it did not reappear. During its retreat, however, it heaped up a well-marked terminal moraine in the form of a hummocky ridge of drift, in places reaching 300 feet above O.D., extending 20 miles in a S.S.W. direction from Mundesley and Cromer.

The Chalky Boulder-clay of Suffolk is blue and intensely Kimeridgian; that of Norfolk is whitish, with a chalky matrix, the boundary between the two being clearly defined. Jurassic Boulder-clay, moreover, may be traced across the Fenland from Suffolk into the Lincolnshire plain, while the chalky drift of Norfolk is represented by the chalky clay which is piled against the western slopes of the southern part of the Lincolnshire Wolds to a height of 300 and 400 feet. The behaviour of the last-named drift is instructive. Due to ice crossing the chalk range through a depression running from north to south in the direction of the present valley of the Bain, it turns suddenly to the south-east as it approaches the lower ground, instead of overflowing the latter, as it must have done had that course been open to it. The separation between the Jurassic and the Chalky Drift is as clearly marked in Lincolnshire as it is in East Anglia. Produced from the former district to the latter, the line dividing them *runs diagonally across the mouth of the Wash.* The author has, moreover, traced a trail of Neocomian erratics for 100 miles in the same direction from the plain of the Witham to the neighbourhood of Ipswich.

These facts suggest the existence of two confluent but distinct ice-streams travelling, *pari passu*, from N.W. to S.E., that which occupied the Jurassic plain being sufficiently the stronger to thrust on one side the ice descending from the Wolds, diverting it towards Norfolk, mounds of Chalky Boulder-clay more or less parallel with the escarpment being accumulated between the two as a medial moraine near Horncastle. This view explains why, at the period in question, the North Sea ice was unable to enter East Anglia through the Wash Gap.

The absence of the intensely Chalky Boulder-clay of South Lincolnshire from the Lincolnshire plain to the west of Market Rasen, where the escarpment is unbroken and more than 500 feet high, indicates that no ice overflowed the Wolds near that place, nor did any cross from the North Sea to the north of the Humber.

It must therefore have been the region south of that river, and north of Caistor, where the Wolds have been broken up and eroded, which supplied the grey flint and hard chalk (other than that of the Norfolk Drift), which is found everywhere in the Chalky Boulder-clay over such an enormous area. So prodigious is the total amount of this débris that, were it brought together, it would almost bridge over the depression now dividing the Lincolnshire from the Yorkshire Wolds.

From the Fenland the Great Eastern glacier fanned out in all directions: to the east over Suffolk, overflowing also the chalk escarpment from Newmarket to Hitchin, from which it travelled down the dip-slope south-eastward into Essex, and southward towards Finchley and St. Albans. To the south-west it occupied the basins of the Welland, the Nene, and the Ouse with a confluent ice-sheet overspreading the higher ground which separates them. Moving along the strike of the Oxford Clay up the valley of the Ouse, it filled that region with Boulder-clay of which the matrix is prevalently Oxfordian; further to the north-west the glacial drift contains a larger proportion of Liassic detritus. The Boulder-clay which covers the chalk region immediately below the crest of the escarpment is, as a rule, very chalky, as is the drift to the west of the Lincolnshire Wolds, and for the same reason, viz., that it was principally the upper and cleaner portion of the ice-sheet which mounted the slopes of the chalk hills. Some Jurassic débris from the Fenland was, however, carried over into Essex, but not enough to give the drift of that region a typically Jurassic character.

Another and an important branch of the Great Eastern glacier passed up the Trent basin. One portion of this climbed the marlstone escarpment near Grantham, and spread Chalky Boulder-clay over the high land to the south of that place; another part followed the Trent valley towards the south-west until it met the ice streams of the Dove and the Derwent, the combined ice-flow being thence southwards up the valley of the Soar. Glacial drift containing, on the one hand, Pennine and Mount Sorrel erratics, and, on the other, Jurassic and Cretaceous débris, may be traced for many miles to the south and south-west of Leicester towards Rugby and beyond.

At one time it was believed that the crescentic moraines of York and Escrick represented the greatest extension of the Teesdale ice. Now, the driftless area to the south of York notwithstanding, it is admitted that the ice reached as far as Barnsley and Doncaster; the comparative absence of drift immediately to the south of those places cannot, therefore, have any value as evidence, in the face of the fact that Chalky Boulder-clay sets in again in great force still further to the south. The enormous area covered by the moraine of the Great Eastern Glacier, 10,000 square miles in extent, is inconsistent with the view that it can have been wholly due to ice crossing the Wolds at the two places named. We seem, therefore, driven to admit the existence of a great ice-stream continuous from the mouth of the Tees to the Fenland, and from the Pennines to the Yorkshire moorlands and the Wolds.

The study of the glacial deposits of the East of England does not appear to support the view that mild interglacial conditions obtained at any time in that region between the deposition of the Cromer Till and the 'cannon-shot' gravels which overlie the Chalky Boulder-clay.

II.—Lake Oxford and the Goring Gap. By F. W. Harmer, F.G.S.

DEEP borings at Sandy, Newport, and Hitchin, and further west at Stony Stratford, reveal the existence of drift-filled valleys, extending in one case to a depth of 140 feet below sea-level, which were probably connected with that of a pre-glacial river running in a north-easterly direction towards the North Sea. Similar deep borings at Boston, Fossdyke, and Long Sutton may represent the mouth or the seaward extension of such a valley.

As far as the Midland Counties are concerned, the gorge at Goring is unique. At no point between Newmarket, in Suffolk, and Blandford, in Dorset, in the one case, or between Lincoln and Bradford-on-Avon on the other, have the Cretaceous or Oolitic ranges been cut down to the base-level of the plains, nor does water run through them from one side to the other. Cases similar to that of Goring occur, however, at three of the places named, as well as at Ancaster, and at Ironbridge, in Shropshire. All these are of a distinct type from the dip-slope valleys of the Oolitic and Cretaceous ridges, and they must have originated in a different manner. They have certain striking features in common. Not only do they cut continuously through the ridges, at right angles to the natural drainage of the plains, but they form narrow, sharply cut, U-shaped gorges, having an extremely modern appearance, as distinguished from the older-looking, wider, and more gradually shelving basins of the dip-slope rivers. They are invariably accompanied by lake-like depressions, lower than the general level of the plains, opening into trumpet-mouthed gorges, through which the former are drained.

Dealing first with the gorges at Lincoln and Ancaster, the effect of the advance of the Vale of York glacier to Barnsley and Doncaster, and the obstruction of the gap separating the Yorkshire from the

Lincolnshire Wolds by the North Sea ice, as explained in a former paper, must have impounded the drainage of the Trent basin and caused the formation of a lake, the overflow of which could only have escaped over some part of the Lincoln ridge. Unless the Lincoln and Ancaster gaps were already in existence, which seems to the author improbable, some such overflow must have been initiated at that time. The continuous advance of the Trent glacier southwards would eventually have blocked the Lincoln gorge, probably with drift, and the Ancaster gap would have been originated, being afterwards similarly blocked, in its turn, as the ice moved on. These channels, however, would have been reopened successively, and probably deepened, when the ice retreated.

Referring next to the case at Goring, we find scattered over the low country round Oxford a number of isolated hills, generally capped by gravel, the origin of which it is not easy to explain on the hypothesis of the fluviatile erosion of the Oxford plain; they present no such difficulty, however, if we regard the latter as the site of an ancient lake, the bottom of which has been gradually lowered.

It has been long known that the gravels in question contain Triassic pebbles, but it is still more important to notice the presence in them, often in great abundance, especially as they are traced towards the gap, of grey Lincolnshire flint.

This flint drift connects itself with a great trail of such detritus extending continuously from Buckinghamshire to the Wolds, being exceedingly common both in the Chalky Boulder-clay of the Ouse basin and in the gravels into which the latter passes towards the south-west.

The grey flints occur in the highest part of the Oxford gravels, at elevations exceeding 400 feet, as, for example, on a hill immediately to the south-west of that place, and at Basildon, near Goring, above the narrowest part of the gorge. The erosion of the Oxford plain, and of its outlet below that level, cannot, therefore, have commenced until after the arrival of the glacial drift in that region.

Other gravels, also containing Triassic pebbles and Lincolnshire flint, occur at a somewhat lower level, representing a later stage in the deepening of the bed of Lake Oxford and of the Gap.

The south-westerly advance of the Chalky Boulder-clay glacier up the Ouse basin, preventing any possible drainage to the east through the Stony Stratford Valley, must have caused the formation of a lake over the comparatively low ground which probably then existed between the Chilterns, the White Horse, and the Cotswold Hills. That the drainage of this lake was from the first in the direction of the present gorge is shown by the presence of flint gravel immediately above it, near the 400 foot contour; it occurs also within it at a lower level. Once started, the drainage has continued to run in the same direction to the present day. The swirl of the water, swollen, especially in summer, by the melting of the ice-sheet which lay close at hand, converging constantly to one point, eventually produced the trumpet-shaped opening which formed such a marked feature of the Gap.

The bottom of the lake, composed of soft Jurassic clay, was gradually deepened, *pari passu* with the excavation of the gorge, the deepest part being always, as shown on the contour maps, near the mouth of the latter, where the erosive power of the escaping water was the greatest.

REVIEWS.

I.—Geology: Earth History. By T. C. Chamberlin and R. D. Salisbury. Vol. II: Genesis–Paleozoic; pp. xxvi, 692, with 306 illustrations. Vol. III: Mesozoic–Cenozoic; pp. xi, 624, with 576 illustrations. (London: John Murray, 1906. Price 21*s.* each net.)

IN continuation of the account of "Processes and their Results," reviewed in our August number, we now call attention to the second and third volumes. They complete this great geological work, and aim at giving an interpretation of the record of the rocks, based on acquired knowledge. In the second volume the story opens with matter that is necessarily more or less imaginative or speculative, matter requiring astronomical, physical, and chemical knowledge, not of great practical moment to the geologist, but full of interest to those who wish to start "In the beginning," with Nebular and Meteoritic hypotheses of the earth's origin; with Cosmology in fact, about one-fifth part of the volume is occupied; and many points briefly mentioned in the first volume are here amplified.

The authors adopt a modified Nebular, or Planetesimal, hypothesis, and mark out the stages of the earth's evolution as (1) astral, (2) molten, and (3) lithic eons, with a practically solid globe; leading on to (4) a primitive volcanic eon, accompanied at first by prodigious volcanic activity, and later attended by sedimentation and the introduction of life. In this last eon we pass from the unknown into the partially known; into the oldest accessible formations, classed in the Archeozoic era. This is the era of schists and granitoid rocks, a complex series including outflows of lava, volcanic tuffs, igneous intrusions of various types, together with sedimentary rocks; all more or less highly metamorphosed, crumpled, and deformed. The presence of life is suggested by carbonaceous shales, certain iron-ores, limestones and cherts, similar to those which owe their origin in part to organic action. This era, it is thought, may have exceeded that of all subsequent time.

Between the Archeozoic and the next era represented in the rocks, there is everywhere great unconformity. This next phase is termed the Proterozoic (a synonym for Algonkian as used by the U.S. Geological Survey). The term is apt to be confused with that of Protozoic suggested by Murchison in 1839, and adopted by Lapworth for the Lower Palæozoic (Cambrian, Ordovician, and Silurian).

In this Proterozoic era it may be said that geological history

practically begins, and the authors deal with the records especially as they are exemplified on the North American continent. The principles which they seek to teach are those applicable to all continents, one object being "to combine dynamical discussion with the phenomena which it is to explain, as these phenomena unfold themselves stage by stage." Thus they deal not only with the local characters of the strata, their subdivisions and their distribution in other areas, but with their physiographic relationships, the features of ancient lands, with sources of sediments, and their mode of derivation. They treat also of the permanence of oceans and continents, and of periodicity in great deformative movements. Evolution and the distribution of faunas and floras are discussed apart from the stratigraphy.

Many interesting comparisons are made and suggested in the course of the work. No distinct physical or organic break is recognized between Cambrian and Ordovician. The Old Red Sandstone is regarded as a phase of the Devonian, some portions of it not improbably having been of subaerial rather than subaqueous origin. Both phases are represented in America.

It is noteworthy, with regard to the basal Devonian, that there is a difference of opinion as to whether the Helderberg formation should be classed as Silurian or Devonian. It has a strong Silurian facies, but the species, as now known, are all new, except *Leptæna rhomboidalis* and *Atrypa reticularis*—the "Methuselahs of Paleozoic times." The authors remark that "the Helderberg formation is largely limestone, which suggests that subaërial erosion was not taking place at a rapid rate, and that the principal formation of the epoch, as far as our continental area is concerned, was extracted from the sea-water." The question of the mechanical derivation of calcareous mud is not apparently taken into consideration.

It is interesting to compare the latest stages of the Carboniferous, locally "Upper Barren Coal Measures," with approximately equivalent strata in England. Great movements were likewise inaugurated at about the close of the Carboniferous period in America.

The Permian, "often regarded as a part of the Carboniferous," was formed in waters either in the form of lakes and inland seas or in connection with the open ocean. The Permo-Carboniferous glaciation in Australia, India, and Africa is spoken of as "the first well deciphered glaciation," though mention is made of that in the Cambrian or pre-Cambrian era. The prevalent red sandstones in the Newark Series show points in common between the Trias in America and England. The Rhætic beds (grouped with the Trias) have not been recognized in America. Jurassic formations have nowhere been determined in the eastern half of the continent, but in western America they occur in nearly the same areas as the Trias. The earliest Liassic fauna is not derived from the locally preceding forms of life, but has the aspect of European Lias, and of the Liassic fauna in Timor Island and in Argentina. In the higher stages *Aucella* and other forms connect with the Upper Jurassic of Russia.

The term 'Comanchean' is applied to the Lower Cretaceous, to include eras from the European Wealden to Cenomanian; the Upper or true Cretaceous being limited to the European Turonian, Senonian, and Danian. The Cretaceous includes the Laramie Series, with sandstone, shale, and coal, also other divisions of clay, greensand, and chalk. It has yielded a remarkable assemblage of vertebrates, especially Saurians (including sea serpents), and birds.

The Cenozoic era is divided into Tertiary (Eocene to Pliocene) and Quaternary (Pleistocene or Glacial, and Recent or Human). Interesting accounts are given of the Eocene and Oligocene faunas and floras. As a rule, the Oligocene has not been differentiated from Eocene in North America, but reasons are given to render the division desirable. It is remarked that pronounced provincialism was inaugurated in the Oligocene, and continued throughout the remainder of the Cenozoic era. The correspondences between the faunas of the western and the eastern sides of the Atlantic during the Miocene period appear to have been "due partly to intermigration and partly to parallel evolution." As pointed out by Dall, the Miocene fauna of North Germany compares well with that of Maryland, while the Mediterranean Miocene is closely allied to the more tropical fauna of the Duplin Beds of the Carolinas. The history of the land animals in Tertiary times is full of interest.

The giants of the Pliocene period were the Proboscideans. "The mastodons seem to have occupied all the continents during the Pliocene, but it is doubtful whether the elephant reached the American continent before the Pleistocene." There must have been migratory routes between Eurasia and America, but there are outstanding problems as to the extent and continuity of the connections at the north-west and north-east.

The Pleistocene is regarded as of shorter duration than the average geological period. "Ice-sheets spread over six or eight million square miles of the earth's surface." More than half of this area was in North America, and more than half of the remainder lay in Europe. The authors remark that "it is not strange that the glacial theory was resisted for half a century, though the iceberg and other glacio-natant hypotheses urged in its stead seem no more credible, and far less adequate. But the cumulative force of a vast mass of evidence, rigorously scrutinized under the promptings of this critical and reluctant attitude, has become overwhelming, and the days of reasonable doubt are passed." That there was a succession of ice-invasions due to fluctuation in the actual limits of the large masses of land-ice, the temporary retreats being accompanied by great floods arising from the melting of the ice, is held by the authors to be borne out by the careful studies of later years; but geologists are not agreed on this part of the subject. "It is not yet known how far the ice retreated in the intervals between the advances," and consequently there are differences of opinion "respecting the estimate to be put upon the importance of the interglacial intervals." In connection with this subject Mr. Lamplugh's recent address to Section C of the British Association at York will be read with interest.

The consideration of the Pleistocene leads us to the Human epoch. At present no evidence has been obtained of man's existence during the Glacial period in America. It is true that implements of 'palæolithic' type have been found, but the term can only be held to indicate a stage of early art; no implements have been discovered in undisturbed deposits of Glacial age.

The sections, maps, the photographic and other illustrations of fossils, and lastly the photographic views of scenery and of rock features, are excellent and most instructive. Vol. ii is accompanied by a small but useful colour-printed geological map of the United States and part of Canada.

Geologists will be grateful for the full and carefully prepared index that accompanies each volume; these indexes will be invaluable aids for reference to the many new and unfamiliar names of local geological formations, rocks, and fossils, as well as to the many topics of interest so lucidly discussed in these volumes.

II.—Ceylon Administration Reports, 1904: Part IV, Education, Science, and Art. Mineralogical Survey: Report of Mr. A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S., Director, Mineralogical Survey.

SOME indication of the excellent work which has been carried out in Ceylon by the Director, Mr. Coomáraswámy, and the Assistant Director, Mr. J. Parsons, under the auspices of the Imperial Institute, is afforded by this interesting report. The extraordinary richness of the island in interesting minerals, including most of the gem varieties, has been long known, but has hitherto not been officially recognised. We hope we may see in a few years the establishment of a permanent Geological Survey. Perhaps the most generally interesting part of the report is that dealing with the minerals containing rare elements. The discovery of Thorianite, which is so rich in thoria, is likely to be of immense commercial importance. We must also allude to the general account of gemming. The richness of the island in gem-stones is evidenced by the fact that upwards of £300,000 worth are exported annually.

The value of the report is increased by the admirable reproductions of photographs with which it is illustrated.

III.—Geological Survey of Western Australia. Annual Progress Report for the year 1905. With two figures. Folio. (Perth, 1906.) Bulletin No. 21: The Geology and Mineral Resources of the Norseman District; Dundas Goldfield. By W. D. Campbell, Assistant Geologist. 8vo; pp. 1–140, with a two-sheet geological map, 5 plates, and 19 figures. (Perth, 1906.)

THE Report, for which Mr. A. Gibb Maitland is responsible, begins with an account of the administrative work of the

Department, including field and laboratory work, geological and mineralogical collections, and publications. These are followed by a detailed account of the principal results of the year's field operations under the heading of "Mineral Resources."

A detailed examination of some of the mining centres in the Pilbara Goldfields was made by Mr. Talbot, and the newly-opened tin-field of Wodgina (of which a sketch-map is given in the Report) was also investigated.

The Mount Margaret Goldfield was examined and reported upon by Mr. C. G. Gibson, who found that the auriferous reefs and lodes occur in 'greenstones,' basic rocks which are essentially hornblendic, and exist both in the massive and schistose state; being similar to those usually forming the auriferous series of the Eastern Goldfields. The "New Find" district, visited by Mr. Gibson, gave very little promise of successful results.

Mr. H. P. Woodward reported upon a portion of the Broad Arrow Goldfield, giving statistics relating to the shafts sunk to reach the reefs at different levels, and particulars of the yield of gold to the ton of ore.

Mr. Woodward also visited the Wagin district for the purpose of reporting upon the possibilities of coal occurring, and upon the reputed phosphatic deposits. From this report, which is given *in extenso*, it appears that the occurrence of coal deposits is somewhat problematical, and that the alleged phosphatic deposits do not contain sufficient quantities to be worked for fertilising purposes.

A very favourable report is given upon the "Sunbeam Lease" gold-mining property, in which the yield has been of the most encouraging character.

The Northern district was visited by Mr. Woodward for the purpose of examining and reporting upon certain gold discoveries. His work was confined to the examination and sampling of those localities where gold was reported to have been discovered. The district as a whole, however, was not found to present any promising signs of good results being achieved by its being worked.

The Report concludes with analyses of various minerals by Mr. E. S. Simpson, mineralogist and assayer to the Survey. These minerals include tantalum, natural nitrates, crocidolite, graphite, and chromiferous laterite.

The work dealt with in Bulletin No. 21 combines both the geology and topography of the district explored, which covers an area of about 46 square miles, embracing, as far as it is understood, the productive area of Norseman.

That portion of the Dundas Goldfield embraced by Mr. Campbell's work consists essentially of a series of metamorphic sedimentary rocks, estimated to reach a thickness, making allowance for repetition by folding, of not more than 800 feet, which occupies a strip of country skirting the west side of Lake Dundas. Some of these ancient sediments appear, according to Mr. Campbell's observations, to have been permeated by secondary silica and oxide

of iron, and are now in places represented by the bands of laminated quartzite and the very ferruginous jaspers, which make a pronounced feature in the field. Associated with the metamorphic sedimentary rocks (some of which are conglomeratic) is a large area of amphibolites, which appears to be embedded with the former; as some of these are distinctly amygdaloidal, there seems very good reason for believing them to be ancient lava-flows. In addition to the amphibolites are a series of diorites and epidiorites, which are apparently interbedded with the sedimentary rocks and amphibolites in such a manner as to suggest the possibility of their being intrusive sills and dykes. Another very important feature is the occurrence of a large number of quartz-porphyry dykes, which traverse the whole of the area mapped in a general north-east and south-west direction. These porphyry dykes in all probability form the apophyses of the large granite mass which lies to the east of, and just outside, the limits of the area mapped.

Although the Norseman district affords no direct evidence as to the geological age of its older basic and acidic rocks, there is good reason to suppose that they all form part of the same series as those which are so largely developed in other parts of the Eastern Goldfields.

Norseman has proved a good mining field, the auriferous quartz reefs being distributed over a large extent of country. Many of the reefs are very rich in gold. Up to the end of 1904 the area embraced by Mr. Campbell's labours has produced 266,004 oz. of gold, or at the rate of 1,019 oz. for every ton of ore crushed. The superficial deposits have yielded only a limited amount of alluvial gold, the total reported from 1899 to 1904 being 1662·37 oz.

This report contains much valuable information relating to the history, topography, water supply, and other details of the district covered. There are also tables of analyses, lists of mineral and geological specimens, and an index to the names of places, mines, leases, reefs, etc. A. H. F.

IV.—Memoirs of the National Museum, Melbourne. No. I: On a Carboniferous Fish Fauna from the Mansfield District, Victoria. By Arthur Smith Woodward, LL.D., F.R.S. 8vo; pp. 1–32, 11 plates. (Melbourne, January, 1906.)

THIS interesting memoir contains a description of a collection made in 1888, at the request of the late Sir Frederick McCoy, by Mr. George Sweet, F.G.S. The specimens, which are in a very imperfect state of preservation, were originally described by McCoy, who selected with great judgment the material for the plates which accompany the memoir. His preliminary determinations (Rep. on Palæont. for 1889, Victoria: Ann. Rep. Sec. Mines, 1889 (1890), pp. 23–24) and his conclusions as to the affinities of the fish-fauna prove, however, to have been almost entirely erroneous. Far from displaying a "mixture of Lower Devonian, and types related to

some of the Calciferous Sandstone Series," as McCoy supposed, the Mansfield fishes are typically and essentially Carboniferous. "Of the six genera represented in the collection, one (*Eupleurogmus*) is too imperfectly known for discussion; four of the others (*Acanthodes, Ctenodus, Strepsodus*, and *Elonichthys*) have hitherto been discovered only in the Permian and Carboniferous of Europe and in the Carboniferous of North America; while the sixth (*Gyracanthides*) is related to an essentially Carboniferous fish in the northern hemisphere, and bears every mark of belonging to the same late Palæozoic period." *Gyracanthides*, which McCoy was correct in recognizing as a close ally of *Gyracanthus*, is regarded by Dr. Smith Woodward as a remarkable discovery. The new specimens prove *Gyracanthides* to be a typical Acanthodian belonging either to the Diplacanthidæ or to a distinct family marking the culmination of this series. The fins exhibit peculiarities indicating a high degree of specialization, which was analogous to that observable in later geological periods among Selachians and Teleosteans.

The Mansfield fishes are such as often occur in estuarine and fresh-water strata in the northern hemisphere, though all the genera are occasionally found in sediments of marine origin. Their association with the remains of land plants suggest estuarine conditions.

The systematic descriptions are illustrated by 11 lithographic (rock-colour tinted) plates, with three figures in the text, one of which is a restored drawing of the remarkable Acanthodian *Gyracanthides Murrayi*.

The following are the species described and figured:—

Gyracanthides Murrayi, sp. nov.
Acanthodes Australis, sp. nov.
Eupleurogmus Creswelli, McCoy.
Ctenodus breviceps, sp. nov.
Strepsodus decipiens, sp. nov.
Elonichthys Sweeti, sp. nov.
E. gibbus, sp. nov.

A. H. F.

CORRESPONDENCE.

THE MODE OF ACCUMULATION OF THE SOUTH DEVON RED SANDSTONES AND CONGLOMERATES.

SIR,—I am glad to see that Mr. Hobson[1] has attacked the perplexing problem of the mode of accumulation of the Devonshire red conglomerates. The remark of mine which he quotes was not intended to throw any doubt on the fact that water was the agent: the difficulty is to conceive any probable mode of action. The Torbay evidence is much as follows. In the English Channel, a few hundred yards south of Berry Head, is a rocky islet, and in its limestone there is apparently a pipe, or small swallow-hole, filled with red sandstone. In the eastern face of Berry Head there is, if I remember aright, a small fissure filled with sandstone. In the

[1] See GEOL. MAG., July, 1906, pp. 310–320 (Pl. XXIA).

Berry Head quarries there stood for long a large dyke of red rock left isolated by the quarrying of the limestone. This, I believe, was subsequently carried off to build a church with. All these I have only observed from the water. On the strand under the old Naval Hospital are the celebrated intersecting Permian dykes, and near the breakwater there is a massive dyke in the low cliff. There appears to be a mass of sandstone in the quarry between Brixham and Fishcombe Cove; and in the northern boundary limestone of the Fishcombe Valley and Cove there is a pipe filled with sandstone. Small dykes occur in the rocks between Elbury and Broadsands, and north of Broadsands there is an outlier of pure sandstone abutting on the limestone under the railway. All the foregoing are fine sandstones. But a few hundred yards further north, in Saltern Cove, we have the celebrated case of the stratified conglomerate lying on the planed edges of the Lower Devonian thin-bedded slates and grits.

Then on the south face of Roundham Head we have the section figured by Mr. Hobson,[1] but further east on the same face we find a much more intricate and incomprehensible example of the most complex false-bedding, with contemporaneous erosion and alternate beds of rough conglomerate. Then on the Paignton side of Roundham Head there is, or was, a cliff-face showing their bedding with one rippled surface; and I once noticed a slab on the beach with what I took for rain-pittings. Sun-cracks are occasionally discernible. Nearer Torquay, on the coast south of Livermead Head, I noticed a bed of fine sandstone which had been channelled and covered with a bed of conglomerate filling the channel. At Corbons Head, near the Torquay railway station, we have some Poikilitic sandstone. Lastly, at Labrador, north of Teignmouth, we have the volcanic breccia overlying the ordinary conglomerate; some of this breccia being of peculiar altered rocks with blue tourmaline, whose origin of derivation has never been positively located. Further on, beyond Teignmouth, we have the often described large masses and blocks, associated with the conglomerates. Now between placid lake shores and the most raging torrents any one of the above cases could be tentatively explained; but to account for every variety of water action, from sun-cracks and ripple-marks to torrential action over scores of miles in area, this is difficult.

Two or three details clash with authority, and at first sight with the laws of nature, especially of hydrostatics and mechanics. No alternate currents in opposite directions could produce the Roundham Head false bedding, and for a current to cover and fill up channels of fine sand with stones is contrary to the axiom that it takes a more rapid current to carry away stones than it does to remove sand.

In a paper privately printed some years ago I described an hour's experiments with currents and sand, and pointed out how there may be two and even three parallel streams at the same time rolling sand both to right and left and producing intricate overlapping

[1] See July Number, Pl. XXIA, Fig. 1.